Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A280.29
F22
Cop. 2

Farm-to-Plant Bulk and Can
Milk Hauling Costs

LIBRARY
CURRENT SERIAL RECORD
★ MAY 1 1956 ★
U. S. DEPARTMENT OF AGRICULTURE

BY JOSEPH M. COWDEN

FARMER COOPERATIVE SERVICE
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D. C.

Service Report 18 *March 1956*

United States Department of Agriculture
FARMER COOPERATIVE SERVICE
Washington, D. C.

Joseph G. Knapp, Administrator

*****

CONTENTS

Page

Summary 1
How study was conducted 2
    Purposes 2
    Sources of information 3
    Methods of analysis 5
Truck operating costs 6
Comparative hauling costs 10
    Actual operations 10
    Adjusted operations 21
Factors affecting comparative cost relationship 32
    Volume per patron 32
    Length of route 37
    Route volume 41
    Combined effect 44
Route reorganization potential 44
Significance of cost reductions to producers 45
Conclusions and recommendations 50

*****

This study was conducted under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

*****

The Farmer Cooperative Service conducts research studies and service activities of assistance to farmers in connection with cooperatives engaged in marketing farm products, purchasing farm supplies, and supplying business services. The work of the Service relates to problems of management, organization, policies, financing, merchandising, quality, costs, efficiency, and membership.

The Service publishes the results of such studies; confers and advises with officials of farmer cooperatives; and works with educational agencies, cooperatives, and others in the dissemination of information relating to cooperative principles and practices.

*****

SUMMARY

Reduction in farm-to-market transportation costs is one of the principal advantages commonly associated with bulk milk handling methods of operation. The potential for such reduction is a matter of primary concern to producers, haulers and milk handlers.

Accordingly, the Farmer Cooperative Service made detailed analyses and comparisons of route operations of two midwestern cooperative plants. Costs of transporting milk in bulk and in cans were compared and the amount and significance to producers of potential reductions in hauling costs were estimated. The study indicates that bulk milk procurement offers the potential for substantial reductions in milk hauling costs under production conditions common in many dairy areas.

Larger pay loads and less frequent pickup service associated with bulk operations resulted in reductions in time and mileage costs per hundred pounds of milk as compared to can hauling operation. Bulk receiving methods require substantially less labor in the receiving room than customary can receiving methods. Accordingly, bulk trucks can unload at other than established receiving hours with relatively little inconvenience to plant personnel and operations. This added flexibility in receiving hours often permits bulk trucks to serve two or more routes a day as compared to one route served by the typical can truck.

On the basis of these findings reductions in hauling costs on daily bulk routes are not probable when producers of the average size prevailing in most midwestern and eastern markets are served. Even when average production per farm is exceptionally high, potential reductions in hauling costs on daily bulk routes are relatively small. Higher loading time requirements on such routes entirely, or to a large extent, offset the economies of larger loads and fuller utilization of the vehicles. It is not implied that daily bulk route operations may not be practicable under any conditions. Under conditions prevailing in many markets, however, daily bulk operations should not be expected to result in large reductions in average hauling costs.

Every-other-day (E.O.D.) bulk operations offer the potential for much greater reductions in hauling costs than do daily bulk operations. Every-other-day service results, in most cases, in reductions of both time and mileage per hundred pounds of milk hauled. Every-other-day bulk service can result in savings of up to 50 percent of the mileage of the pickup segment of a route, depending on the degree to which road layout and condition permit division of such mileage into two separate runs without duplication. The higher farm stop time requirement per unit of milk associated with daily bulk service is reduced to a level comparable to that on can routes when E.O.D. service is provided and 2 days' milk production is loaded at each stop.

Potential reductions in hauling costs on every-other-day bulk routes as compared to costs on can routes serving the same group of producers are greatest when the producers are large, the distance between producers is great and the procurement area is distant from the plant. Under these conditions reductions in time and mileage due to every-other-day operations are greater than when routes are short and patrons are small and densely located on the routes.

Producers need not be exceptionally large for every-other-day route operations to result in significant reductions in hauling costs. Potential reductions on routes serving patrons averaging 300-400 pounds of milk a day are nearly as great as when patrons average 1,000 pounds a day.

Potential reductions in hauling costs when bulk routes are operated under conditions prevailing in this study can be an important source of revenue to producers. If realized and reflected to producers, they will compensate producers (excluding 1- and 2-can patrons) for a significant proportion of their investment in bulk farm cooling equipment. In many cases the potential reduction in hauling costs is sufficient to compensate producers for the entire investment costs incurred in excess of those required for mechanical refrigeration of milk in cans.

Extensive planning and adroit management will be required, however, if anything like the full potential in reduction of hauling costs is to become a reality. Although conversion to bulk methods involves many problems, it is one of the most important recent developments in the dairy industry. Bulk handling is not a panacea. Its contribution to the welfare of the industry will depend largely on the skill with which it is adapted to local conditions.

FARM-TO-PLANT BULK AND CAN MILK HAULING COSTS

Joseph M. Cowden
Dairy Branch
Marketing Division

The dairy industry is now using bulk milk handling methods in many markets supplied by medium size or large herds. Producers in all sections of the country are installing bulk cooling equipment in their milk houses, haulers are equipping trucks with insulated bulk tanks, and receiving plants are altering receiving methods to accommodate bulk receipts. Many cooperatives have been making the change to bulk handling and many others are considering the shift. So the Farmer Cooperative Service of the U. S. Department of Agriculture conducted a study at two midwestern dairy cooperatives to help producers, their cooperatives, and other handlers make some of their decisions on whether to convert to bulk milk handling. This study aimed primarily at providing a realistic estimate of the potential reductions in milk hauling costs when bulk procurement routes operate under conditions common to many areas.

Before 1948, bulk procurement methods were essentially limited to California and Florida fluid milk markets predominantly supplied by large herds. Since that date the development has spread throughout the country. A 1953 survey 1/ showed an estimated 6,150 farm tanks supplying milk to 102 receiving plants in 30 States. A repeat survey conducted by Farmer Cooperative Service of the U. S. Department of Agriculture estimates that 17,700 farm tanks were being used by producers in 46 States in March 1955.

Bulk milk handling procedures not only are a departure from customary practices of handling milk in cans but their implementation involves significant equipment and functional changes by producers, milk haulers and milk receiving plants. Increased investments in cooling, storage and transportation equipment are required. The costs of these increased investments fall mainly on producers and secondarily on the owners of the transportation facilities.

1/ Stocker, Noel. Progress in Farm-to-Plant Bulk Milk Handling. 53 pp. Farmer Cooperative Service Circular 8. p. 7. November 1954.

Acknowledgements:
The author expresses his appreciation to Donald E. Hirsch and others of the Dairy Branch, Farmer Cooperative Service, for many helpful suggestions in the preparation of this publication. He is especially indebted to Noel Stocker, now with the Central Bank for Cooperatives, Farm Credit Administration, who planned the study and essentially completed the fieldwork.

Obviously, producers, haulers and milk handling firms would not be adopting bulk methods unless they anticipated advantages which would offset the costs of the necessary investments. A wide range of claimed advantages and disadvantages of bulk milk procurement operations have been discussed at considerable length in various trade publications.

Most research studies and less formal analysis of the development have indicated a net advantage for bulk methods over can methods when all factors were considered. On the basis of such studies, producers may logically anticipate savings arising from improved quality of milk delivered, reduced losses of milk solids, reduced receiving costs and reduced hauling costs. Such savings in many cases offset the costs of increased investments in equipment for cooling and storing milk on the farm.

Research results essentially have been in agreement about the potential for savings in each of the four categories listed in the previous paragraph. As might be anticipated, however, the extent and significance of the possible savings vary rather widely, depending on conditions under which the various studies were conducted.

There has been a natural tendency to overemphasize the potential advantages of the system by noting exceptional cases. This is particularly true in citing potential reductions in hauling rates. Reductions of 20 cents or more per hundred pounds of milk in the rates charged producers for farm-to-plant hauling service have been given in several cases. It is not likely, however, that reductions in transportation costs associated with the adoption of bulk handling methods can justify such large reductions in hauling rates under conditions prevailing in the average fluid milk market.

HOW STUDY WAS CONDUCTED

This study, therefore, analyzed the potential for savings in adopting bulk handling methods of cooling and storing milk on the farm. We limited the detailed study to the milk transportation phase of procurement operations. No attempt was made to analyze the overall impact of bulk procurement on producers, milk receiving plants or market areas.

Purposes

The specific purposes of the study were:

1. To compare bulk hauling costs with can hauling costs and estimate probable savings to producers under conditions in the cases under review.

2. To determine the effects of variations in volume, length of route and similar factors on the relationship between bulk and can milk hauling costs.

3. To estimate the degree to which potential hauling cost reductions may offset necessary added investment in farm equipment.

In limiting the scope of this study, there is no intention to imply that the potential reduction in hauling costs is the only factor to be considered in deciding whether or not to adopt bulk procurement methods. It is recognized that this is but one of many factors to be considered - several probably of equal or greater significance in the long run than reductions in hauling costs.

Sources of Information

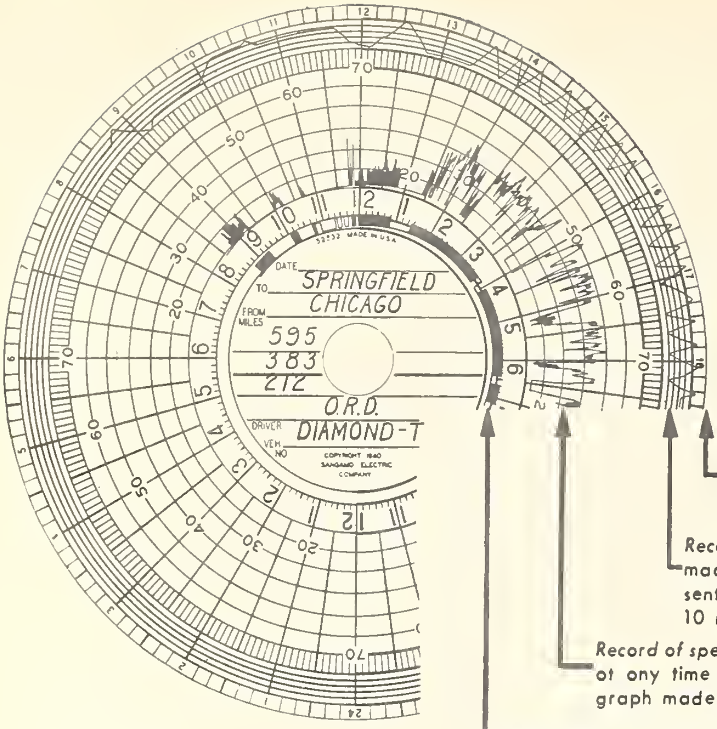
The bulk milk hauling operations described and analyzed in this report represented essentially the initial bulk procurement experience of two large midwestern cooperatives. The bulk routes had been in operation only a few months before our observations. Neither the cooperative plants, the haulers nor the producers involved had previous experience with this type of operation.

The analysis was not an appraisal of the overall procurement operations of the two cooperating associations. The routes included in the analysis constituted in each case a very minor part of the procurement operations of the cooperative.

All the routes were owned and operated by contract haulers. The bulk routes were composed primarily of producers who had been served by the respective haulers on their old can routes. Each of the cooperating haulers, however, at the time of the study continued to operate can routes serving producers who had not installed bulk tanks on their farms. The actual data thus represented bulk hauling in the transition stage with each contract hauler offering both bulk and can hauling service to producers in the area previously covered by his own can trucks.

We obtained operating records for the period June through November 1953 for 3 bulk trucks - 1 delivering to 1 plant and 2 to the second. At the beginning of our observations, these three trucks constituted the entire farm-to-plant bulk hauling operations at the 2 plants. One of the associations started an additional bulk route during the survey period which was not covered in the analysis.

Preliminary plans for the study called for similar detailed records on 3 can trucks, 1 operating in the area of each bulk truck, as a source of comparative data. Due to factors beyond our control, recording equipment on 1 can truck was not maintained in proper operating condition, and usable records were obtained on only 2 can routes.



Record of time: Numbers and divisions on outer circle indicate time of day as reference points for determining time of occurrence of all recorded data.

Record of miles traveled: Saw-tooth graph made here. Distance between lines represents one mile. Each red saw-tooth indicates 10 miles.

Record of speed: The exact speed occurring at any time can be determined from the graph made here.

Record of operation: Records when engine is off, when engine is idling and when truck is in motion.

Type of recording chart used to obtain time and mileage records

We obtained detailed time and mileage records on route operations by special recording speedometers on the route trucks. These meters recorded time, speed, and distance on recording charts, a sample of which is pictured above. By use of this device it became practicable to collect detailed time and mileage records over an extended period of time. Stop watch observation methods are not practicable except for a limited number of observations.

Reading the charts gave a detailed record of each truck's daily operations. This record included distance and rate of travel, time of stops and time between stops not only for the route as a whole but for each individual farm stop. It was thus possible to associate time of individual farm stops with the volume of milk loaded at the stop. The total daily time and mileage records obtained by this method are exceedingly accurate. Although some difficulty was experienced in reading the time of individual farm stops due to occasional unscheduled stops, changes in the order of pickup on the route and other similar irregularities, careful reading of the charts resulted in a reasonably accurate matching of time and volume on the individual farm stop basis.

Supplemental information and records were obtained under contractual arrangements with the cooperating plants and haulers. The plants tabulated daily records of volume of milk delivered by each producer on the routes involved.

Haulers, in addition to providing the daily charts previously mentioned, maintained daily records of the direct truck operating expense. They also provided detailed information on their investment in hauling facilities and a record of fixed annual expense items such as insurance, licenses, and the like. These records were the source of truck operating cost data used except for 2 items -- tire expenses and repairs. Actual expenditures for a 6-month period were not regarded as an accurate index of long-run costs in these cases -- especially since equipment being used was relatively new. Estimates of these two items have been made on the basis of other studies of truck operating costs.

Method of Analysis

As a first step, we summarized actual operating data of the routes and calculated returns per hour and per mile. Wide variations between routes in the inputs of labor and truck mileage per unit of milk became apparent.

Direct comparisons of the results of these actual route operations were interesting but should not be considered indices of the relative economies of the two systems of hauling. Direct comparisons were misleading to an unusual degree in these cases since the bulk routes were formed by withdrawing the largest producers from the can routes. The comparison of actual operating data was thus between bulk routes serving a few of the largest producers and can routes serving the remainder of the patrons in the area. Neither type of route was serving average producers at the time data were collected.

The principal value of our observation of the actual operating data was in obtaining measures of time requirements which enabled us to make estimates of operating costs for the two methods of hauling under a variety of operating conditions.

In order to remove the above mentioned and other noncomparable elements we constructed a series of synthetic routes utilizing time and distance factors based on the actual operating data. As a first step each of the five original routes were used as models holding size and location of patrons and method of operation consistent with the actual data. The number of patrons served and the length of route, however, were adjusted to maximize the average daily load, taking seasonality of production into consideration.

As a second step, we developed can routes using average volume and location of patrons as illustrated by each of the bulk routes. Likewise, bulk routes operating on both the every-day and every-other-day basis were constructed with patrons similar in size and location to those served by each of the original bulk and can routes.

Next we constructed routes serving average volume producers -- the average of those served by both can and bulk routes -- in the two procurement areas in which both types of operating records were obtained.

In each of these cases inputs of time and truck mileage per hundredweight of milk were calculated. These inputs were converted to "cents per hundredweight" hauling costs by applying calculated truck operating costs and assumed hourly labor rates. This procedure resulted in (1) a direct comparison in terms of inputs and "cents per hundredweight" costs on bulk and can routes as they actually operated, and (2) a similar comparison of the two types of routes when the principal factors influencing the potential economies were held constant.

Finally, we constructed routes demonstrating the influence of variations in volume per day, length of route, and similar factors on the relationship between bulk and can milk hauling costs.

In all these analyses the 1,500 gallon tank truck was compared with the normal midwestern can truck with a capacity of 125 to 150 cans. It was not a comparison of equal sized loads under the two systems of operations. It was a comparison of a common tank truck operation with a common can truck operation.

The term "production" as used in this report means "volume of milk produced for sale."

TRUCK OPERATING COSTS

The net vehicle weight of the three tank trucks included in this study averaged approximately 10,500 pounds. The capacity load in each case exceeded the rated capacity of 1,500 gallons and averaged 13,400 pounds. The pay load thus constituted 56 percent of gross weight when the tanks were loaded to capacity. The trucks actually hauled an average load of 11,887 pounds of milk during the 6 months for which operating cost records were obtained.

The net vehicle weight of the two can trucks averaged 9,800 pounds, about 7 percent less than the 1,500 gallon tank vehicles. These trucks had an average capacity of 138 cans. The capacity pay load of these can trucks was 9,660 pounds of milk at the rate of 70 pounds of milk per can. Total capacity load weight -- milk and cans -- was 13,110 pounds or only 3 percent less than capacity load of the tank trucks. The pay load of milk, however, constituted only 42 percent of gross weight when the vehicles were loaded to capacity, an additional 15 percent being accounted for by the weight of cans. The can trucks carried an average actual load of 110 cans containing 7,570 pounds of milk with a total load weight of 10,320 throughout the 6 months period.

The average gross weight of the tank trucks when loaded to capacity was approximately 23,900 pounds as compared to 22,900 pounds for the can trucks. The gross loaded weight of the larger of two can trucks was slightly in excess of that of the heaviest of the three tank outfits.

The average costs of operating these trucks are summarized in table 1. Total variable costs for the individual bulk trucks ranged from 7.7 cents to 8.6 cents per mile of operation. This compared with variable costs ranging from 8.4 and 8.1 cents for the two can trucks. Average variable costs of the two can trucks exceeded similar costs for the tank trucks by approximately 1/3 of a cent per mile.

This difference was accounted for entirely by higher per mile gasoline costs. The two can trucks averaged 6.98 and 6.61 miles per gallon of gasoline. One tank truck covering a short route with distances between stops comparable to the can trucks drove 6.93 miles per gallon of gas. The other two tank trucks serving longer routes and also utilized, in part, for over the road inter-plant hauls averaged 7.42 and 7.47 miles per gallon. Prices actually paid for gas by these trucks ranged from slightly under 24 cents to 28.8 cents a gallon. A uniform rate of 25 cents a gallon was used for purposes of comparison.

The cost per mile for tires and tubes was estimated on the basis of new tire and recapping costs supplied by the truck operators. Haulers' estimates of tire life on the can trucks, with which they had long operating experience, resulted in per mile costs comparable to that reported in other studies of trucks operating under similar conditions. The cost of tires and tubes was calculated as 1.32 cents per mile, as compared to 1.38 cents in a study of can hauling costs in the Fort Wayne milkshed. 2/

These haulers had little experience with the operation of tank trucks and their estimates of tire life for such operations ranged from 65,000 miles with one recap to an extreme of 150,000 miles with two recaps. These estimates were considered too optimistic. The 1.42 cents per mile cost used in table 1 is based on a life of 85,000 miles with each tire being recapped twice.

Actual expenditures for repairs on these trucks during the 6 months for which records were obtained were relatively insignificant ranging from 0.1 cent to 0.4 cent per mile. Such expenditures, however, cannot be considered as indicative of the true costs, calculated on the basis of expenditures throughout the life of the truck. In the absence of such records the 2.8 cents per mile cited in this comparison of costs is based on average cost data supplied by the International Harvester Company. 3/

2/ Pritchard, Norris T. and Cope, William H. Milk Assembly in the Fort Wayne Milkshed. 24 pp. Ind. Agr. Exp. Sta. Bul. 559. p. 12. Lafayette. 1951.

3/ Holmes, J. W. - Letter of Feb. 25, 1954, addressed to attention of Noel Stocker.

Table 1. -- Milk truck operating costs

Item	Average of 3 bulk trucks		Average of two can trucks	
	Dollars per year	Cents per mile	Dollars per year	Cents per mile
Variable costs a/				
Gasoline at 25¢ per gal.	$ 509	3.39¢	$ 560	3.73¢
Oil and grease	44	.29	54	.36
Tires and tubes	213	1.42	198	1.32
Repairs	420	2.80	420	2.80
Total variable costs	1,186	7.90	1,232	8.21
Fixed costs				
Depreciation - truck	610	4.07	456	3.04
Depreciation - tank or van	422	2.81	79	.53
Maintenance - tank and equipment	200	1.33	50	.33
Licenses	129	.86	134	.89
Insurance	283	1.89	142	.95
Garage rent	180	1.20	180	1.20
Interest - truck	85	.57	66	.44
Interest - tank or van	123	.82	18	.12
Total fixed costs	2,032	13.55	1,125	7.50
Total cost a/	3,218	21.45	2,357	15.71

a/ When truck is operated 15,000 miles per year.

On the basis of these limited data it appears that there is no substantial difference in variable operating cost per mile between bulk trucks and can trucks when the average gross loaded weights are comparable.

The average annual fixed cost on the bulk trucks was $2,032 as compared to $1,125 on the can trucks. Annual fixed costs ranged from approximately $1,800 to $2,345 on the bulk trucks and from $1,025 to $1,225 on the can trucks. This substantial difference was due principally to the high initial cost of the truck tanks and necessary supplementary equipment as compared to the cost of the van bodies for the can trucks. The average investment in the three bulk vehicles was $9,200 as compared to less than $3,600 in the can trucks. This higher investment resulted in higher depreciation, interest, and insurance charges. Investments in the individual hauling units and the calculation of annual depreciation charges are detailed in the appendix table 1.

Annual charges for licenses, insurance, and garage rent were those reported by the haulers. An estimated fixed charge of $200 per year was included for maintenance of the tank and its equipment based on estimates of pump and motor repairs, hose replacements, painting, and similar items submitted by the haulers. An estimated $50 for painting and maintenance of the can vans also was included. Interest charges were calculated on the undepreciated balance of the investment at the rate of 4 percent per year.

On the basis of a relatively low annual utilization of 15,000 miles, the fixed cost per mile on the tank trucks was 13.55 cents as compared to 7.50 cents for the can trucks. Total costs under these conditions of operation were 21.45 cents and 15.71 cents for tank and can trucks, respectively.

Due to the higher ratio of fixed costs to variable costs, the total cost per mile of operating the tank trucks declines much more rapidly than that of the can trucks as the annual mileage increases. Although the cost per mile of operating the tank trucks substantially exceeded that of the can trucks, there was only slight difference in the costs per hundredweight per mile. Assuming that tanks and can trucks each hauled an average load of 80 percent of capacity the total operating cost was 0.2 cents per hundredweight per mile in each case when the truck was operated 15,000 miles per year. At 30,000 miles per year the per hundredweight per mile cost was 0.146 cents for the tank truck and 0.160 cents for the can truck. The per hundredweight per mile cost advantage of the tank truck increases as the annual mileage utilization increases. The larger pay load -- weight of milk hauled by the tank truck -- more than offset higher fixed costs when costs were compared on a per hundredweight per mile basis and the annual utilization exceeded 15,000 miles. This changing relationship would not exist if comparisons were made between tank trucks and can trucks hauling equal loads of milk. It is an economy resulting from the larger load -- made practicable by utilization of the bulk truck -- rather than an economy of the tank truck as such.

COMPARATIVE HAULING COSTS

The value of direct comparisons of costs of actual milk route operations is highly dependent on the degree of uniformity in the composition and structure of the routes. Routes analyzed in this study were not uniform in character. Accordingly, both actual and adjusted bulk and can route operating costs are compared in this section.

Actual Operations

Operations of the three bulk routes were comparable on the basis of capacity of the vehicles used and average loads hauled. However, as indicated by operating data summarized in table 2, wide variations between routes were characteristic of most of the other factors affecting operating efficiency. All data in this table and the following one containing similar data on can truck operations are averages per trip for the 6 months period June-November 1953.

The first bulk truck, B1 in table 2, served a comparatively short route and operated on a one trip per day basis. It collected milk daily from all patrons. Producers served delivered an average of 836 pounds of milk a day. This operator could maintain a high average load for two reasons. Production of the farms served was relatively even when compared to average seasonal variations for the area, and two new patrons were added to the route as production declined seasonally. The daily farm-to-plant operation was the only use made of this truck.

The other two bulk vehicles provided a contrast to the relatively even day-to-day operating pattern of this truck. At the beginning of our observations in June, the second truck, B2, was serving 12 producers on an every-other-day pickup basis. It also served daily one additional large producer, whose farm tank would not hold 2 days' production. The truck operated on a schedule of 3 loads each 2 days during June and July.

The volume of milk loaded at the farm was insufficient to fill out 2 of the 3 loads -- but the association to which the milk was delivered assisted the bulk trucks operations during the route development period by permitting them to "top-off" -- that is, fill out incomplete loads at country receiving stations operated by the association. The farm service bulk trucks were also used to a limited extent for interplant hauling. This utilization of contract haulers' equipment materially reduced per mile and per hundredweight overhead charges against the bulk farm pickup service.

Table 2. -- Summary of bulk milk truck operations, June-November 1953

Item	Unit	Truck number		
		B1	B2	B3
Farm-to-plant operations				
Loads hauled	Number	183	219	142
Producers served by the truck	Number	14.6	10.7	15.2
Frequency of service	-	Daily	E.O.D.	E.O.D.
Producers served per trip	Number	14.6	4.83	9.8
Milk load per trip				
Loaded at farms	Pounds	12,208	10,747	8,981
Loaded at receiving stations	Pounds	-	936	2,369
Total	Pounds	12,208	11,683	11,350
Capacity of truck tank	Pounds	13,240	13,330	13,900
Capacity utilized	Percent	92	88	82
Average length of trip	Miles	45.5	112.7	225.7
Milk hauled per mile	Pounds	268	104	50
Milk hauled per producer per trip	Pounds	836	2,224	916
Total time per trip	Hours	6.63	7.57	10.19
Total time per cwt. milk	Minutes	3.26	3.89	5.38
Average hauling rate				
Farm to plant	Cents per cwt.	20.0	19.4	35.00
Receiving station to plant	Cents per cwt.	-	9.25	12.35
Average rate	Cents per cwt.	20.0	18.58	30.26
Inter-plant operations				
Trips	Number	None	89	21
Average load	Pounds		12,112	13,893
Average length of trip	Miles		91.7	145.3
Average time per trip	Hours		3.8	5.0 1/
Milk hauled per mile	Pounds		132	96
Time per cwt. milk	Minutes		1.73	2.16
Average hauling rate	Cents per cwt.		10.23	16.00

1/ Estimated.

At the end of July several producers were transferred to a new bulk truck route (not included in our study), and the original route operated on a straight one trip per day E.O.D. (every-other-day) service basis until the latter part of November. Patrons and volume were gradually added to the route and a 3-trips each two day schedule was again in effect during the last 2 weeks of November. The outstanding feature of this route was the fact it served an average of only 4.83 producers each trip. These producers provided 92 percent of the average load, the remaining 8 percent being loaded at the country receiving stations. The average volume loaded per farm stop, that is, for 2 days' production, was 2,224 pounds.

The third route, B3, differed from the other two in that it was much longer and served much smaller producers. The average E.O.D. delivery was only 916 pounds per patron -- about 40 percent of that of the other E.O.D. route and less than 10 percent larger than average deliveries on the daily route. During June and part of July, this route operated on a daily basis, serving half of the producers each day. Loads were "topped off" at a can milk receiving station. From July through October the truck operated on an every-other-day basis, serving all producers on the same trip.

Increasing fall production and the addition of three producers made it possible to resume regular daily trips on an E.O.D. service basis late in October. "Topping-off" at the receiving station continued on a reducing scale throughout the 6 months period. Although this truck served more than twice as many patrons per trip as the other E.O.D. truck and averaged only 3 trips each 4 days, it was dependent on the receiving station for approximately 20 percent of its volume.

In table 3, can route C1 was owned by the operator of the shortest of the three bulk routes. It operated on a regular one trip per day schedule. Shippers on this route delivered an average of 375 pounds of milk per day as compared to the 836 pound per day average of bulk shippers in the same area. The can truck traveled approximately the same distance per day as the bulk truck. Although it served more patrons, it transported only 53 percent as much milk as the bulk truck.

The second can truck, owned by the operator of the second tank truck, provided daily pickup service for can shippers in the same area. It made two trips a day during June and most of July and one trip a day thereafter. It provided milk transportation service for an average of 22.3 producers a trip as compared to the 4.83 producers served by the bulk truck. The can shippers, however, produced an average of only 377 pounds of milk a day as compared to 1,112 pounds for the bulk shippers. Much smaller daily production and daily pickup service, as compared to E.O.D. service on the bulk route, more than offset the additional number of producers served. As a result the can truck load was approximately 20 percent less than that of the bulk truck.

Table 3. -- Summary of farm-to-plant can truck operations, June-November 1953

Item	Unit	Truck number	
		C1	C2
Loads hauled	Number	183	237
Producers on route	Number	17.3	28.4
Frequency of service	-	Daily	Daily
Producers served per trip	Number	17.3	22.3
Load per trip			
Total milk hauled	Pounds	6,491	8,417
Cans hauled	Number	94	123
Weight of cans (25 lbs. each)	Pounds	2,350	3,075
Total load weight	Pounds	8,841	11,492
Capacity of truck - cans	Number	126	150
Capacity utilized	Percent	75	82
Cans per producer	Number	5.4	5.5
Milk per can	Pounds	69.0	69.0
Average length of trip	Miles	44.2	103.9
Milk hauled per mile	Pounds	147.0	81.0
Milk hauled per producer	Pounds	375.0	377
Total time per trip	Hours	3.71	7.82
Total time per cwt. of milk	Minutes	3.43	5.57
Hauling rate	Cents per cwt.	17.5	22.9

Further variations in the operations of these routes are apparent in the breakdown of time and mileage requirements shown in table 4. The most important difference between the individual routes and between the bulk routes and the can routes was in the farm stop time per producer served. The average stop time at each farm -- the time the truck was not in motion -- averaged 10.1, 23.5 and 9.1 minutes on the three bulk routes as compared to 3.9 and 4.3 minutes on the two can routes.

Another pronounced difference between the bulk routes and the can routes was in the average distance between patrons on the routes. This difference was most pronounced in the case of the second bulk route, (B2) table 4, which traveled 23.3 miles for each producer served while the can route (C2) operating in the same area traveled only 4.7 miles per patron.

The average distances between patrons within the pickup sections of these two routes were 10.8 and 2.6 miles, respectively. The contrast was less pronounced in the case of the short routes, but the average distance between patrons on the bulk route was again in excess of that on the comparable can route. It was thus clear that the bulk routes were in each case composed of a selection of the largest producers in the area served. In each of the two cases where data for can routes were available for comparison, the greater distance per patron on the bulk route was more than offset by the increased volume per patron. The net result was much lower mileages per hundred pounds of milk on the two bulk routes than on the can routes of comparable length.

Visual inspection of day-to-day records of time spent at the plants by these trucks indicated that variations in such time were only remotely related to the volume of milk or number of cans to be unloaded. All other conditions being equal, the time required to unload naturally increased as volume increased.

In actual practice, however, the relatively small variations in time due to day-to-day and month-to-month variations in volume were almost obscured by irregular and largely unpredictable variations in the amount of time the truck had to wait at the plant before it moved up to the unloading dock.

The total time at the plant for a tank truck may be expected to exceed that for a can truck due to the time required to wash and sterilize the tank after unloading. This situation existed at one of the two plants included in this study but not at the other. The average time spent at the plant by one of the tank trucks, B1, table 4, was 85.1 minutes a trip. The can truck delivering milk to this same plant averaged 39.8 minutes a day and would have spent an estimated 61 minutes had it carried the same volume of milk as the tank truck. There was relatively little traffic congestion at the can unloading dock of this plant and essentially no delay in unloading the tank truck.

Table 4. Breakdown of mileage and time requirements
for bulk and can milk hauling

		Truck number				
Item	Unit	B1	B2	B3	C1	C2
Mileage						
Length of route	Miles	45.5	112.7	225.7	44.2	103.9
Proportion pick-up	Percent	69.0	37.0	44.0	67.0	52.0
Proportion over-the-road	Percent	31.0	63.0	56.0	33.0	48.0
Total route distance per producer	Miles	3.1	23.3	23.0	2.5	4.7
Average pick-up mileage between producers	Miles	2.3	10.8	11.2	1.8	2.6
Miles per cwt. of milk	Miles	.37	.96	1.99	.68	1.23
Travel time per trip						
Total	Minutes	117.8	182.7	364.6	111.3	201.6
Proportion between farm stops	Percent	72.0	41.0	47.0	71.0	62.0
Proportion over the road	Percent	28.0	59.0	53.0	29.0	38.0
Rate of travel						
Total	MPH	23.2	37.0	37.0	23.8	30.9
Between farms	MPH	22.4	33.1	34.9	22.6	26.1
Over the road	MPH	25.2	39.7	39.2	26.7	38.7
Stop time						
Total	Minutes	280.0	271.6	246.5	111.5	267.6
At farms	Minutes	147.2	113.3	89.2	67.8	96.0
At plant	Minutes	85.1	120.0	115.0	39.8	118.9
Other stops	Minutes	47.7	38.3	42.3	3.9	52.7
Farm stop time per producer	Minutes	10.1	23.5	9.1	3.9	4.3
Time per cwt. of milk						
Farm stops	Minutes	1.21	1.05	.99	1.04	1.14
At plant	Minutes	.70	1.03	1.01	.61	1.41
Other stops	Minutes	.39	.33	.37	.06	.63
Travel	Minutes	.96	1.56	3.21	1.72	2.39
Total	Minutes	3.26	3.89 1/	5.38 1/	3.43	5.57

1/ Detail of items do not add to these totals since farm stop time is calculated on basis of milk pickup at farms and other items on basis of total load including milk loaded at receiving stations.

The remaining trucks, B2, B3, and C2, unloaded at a plant where congestion at the unloading dock was a problem. Both the can trucks and the tank trucks often encountered long delays waiting for trucks ahead to unload. This plant used a large pump for unloading and the actual pump-out time for the two bulk trucks, determined by stop watch observations during visits to the plants, was approximately 12 minutes as compared to 34 minutes at the first plant. In spite of this reduced pump-out time, these trucks averaged 35 and 30 minutes more at the plant than the other bulk truck.

A similar situation existed with the can truck. It averaged nearly 119 minutes per trip at this plant as compared to approximately 40 minutes for the can truck delivering to the non-congested plant. There was very little difference between the average time spent by bulk trucks and can trucks at this plant. Both of the can trucks hauled A and B grade milk. The unloading operation thus involved stops at two unloading docks. At the first plant, the shift between A and B grade receiving lines involved a move from one side of a relatively small plant to the other, usually accomplished with little or no delay. In the second case, truck C2, grade A was typically unloaded at a grade A plant and grade B at a manufacturing plant some 5 or 6 blocks away. Waits in line at two separated unloading lines were thus involved.

"Other stop" time shown in table 4 was composed principally of fuel and coffee stops en route. It also included "top-off" stop time for the two bulk trucks following this practice. The total amount of such time was fairly uniform between routes with two exceptions. The driver of C1 did not stop ordinarily for either lunch or gas during the course of his route. For 4 of the 6 months the second can truck was hauling essentially a full double-decked load of cans. Special double decking stops averaging about 20 minutes a trip were included in "other stop" time.

The average travel time on these routes -- the total time the trucks were actually in motion -- was in general related to the length of the route and the density of patronage on the route. Trucks on short routes with dense patronage operated at relatively low speeds. The trucks on the long routes with infrequent stops maintained the highest average speeds. As would logically be anticipated, the average speed maintained over the "pickup" section of the route was, in each case, substantially less than the "over-the-road" speed of the trucks. The "over-the-road" sections of the two tank routes on which average speeds of 37 miles per hour were maintained were composed almost entirely of good concrete highways and running speeds approaching 60 miles per hour were observed when we rode these trucks. In other studies it has generally been assumed that other factors being equal, bulk trucks and can trucks might be expected to operate at equal speeds. The limited data obtained in this study appear to support such an assumption.

The total unit time requirements on two of the bulk routes were in each case less than the time requirements on the can routes of comparable length. These lower time requirements were the result of larger patrons and larger loads hauled on the bulk routes. They could be considered as an economy of bulk hauling only to the extent that the larger loads were made practicable by utilization of bulk equipment.

As previously indicated the difference in farm stop time for each producer served was perhaps the most important variation between the bulk and can route operations summarized in tables 3 and 4. This difference required further analysis.

The additional time required at the farm on the bulk routes was primarily the result of two factors -- the additional functions performed at the farm by the tank truck operator and the larger volumes of milk handled. Other analyses of farm stop time requirements have shown that high fixed time requirements with a comparatively low rate of increase as volume increases are characteristic of bulk routes. Low fixed time requirements and a relatively high rate of increase as volume increases are typical of can route operations. Clark 4/ found, for example, that the farm stop time on bulk routes was 10.1 minutes plus .0167 per gallon of milk loaded while on can routes it was 2.12 minutes plus .457 per can loaded. Reduced to a per pound basis the rate of increase in time as volume increased was thus .002 minutes on the bulk routes and .007 minutes on the can routes.

The relationship between time per farm stop and the volume of milk loaded on the five routes included in this analysis is illustrated in figure 1. 5/

Total farm stop time on the two can routes followed a similar pattern -- starting at approximately the same level and increasing at similar rates as volume per stop increased. The difference in farm stop time requirements between two of the bulk routes, B1 and B3, was essentially accounted for by differences in the capacity of pumps used. Although functions performed on the third bulk route, B2, were the same, the amount of time spent at the farms was greatly in excess of that required for equal volumes on either of the other routes. The difference was in the fixed time factor which was 18.5 minutes per stop as compared to 6.8 and 6.5 minutes on B1 and B3, respectively. No explanation for this difference was apparent. Clark 6/ found that the fixed time factor on bulk routes he studied varied from 5.7 minutes to 19.2 minutes.

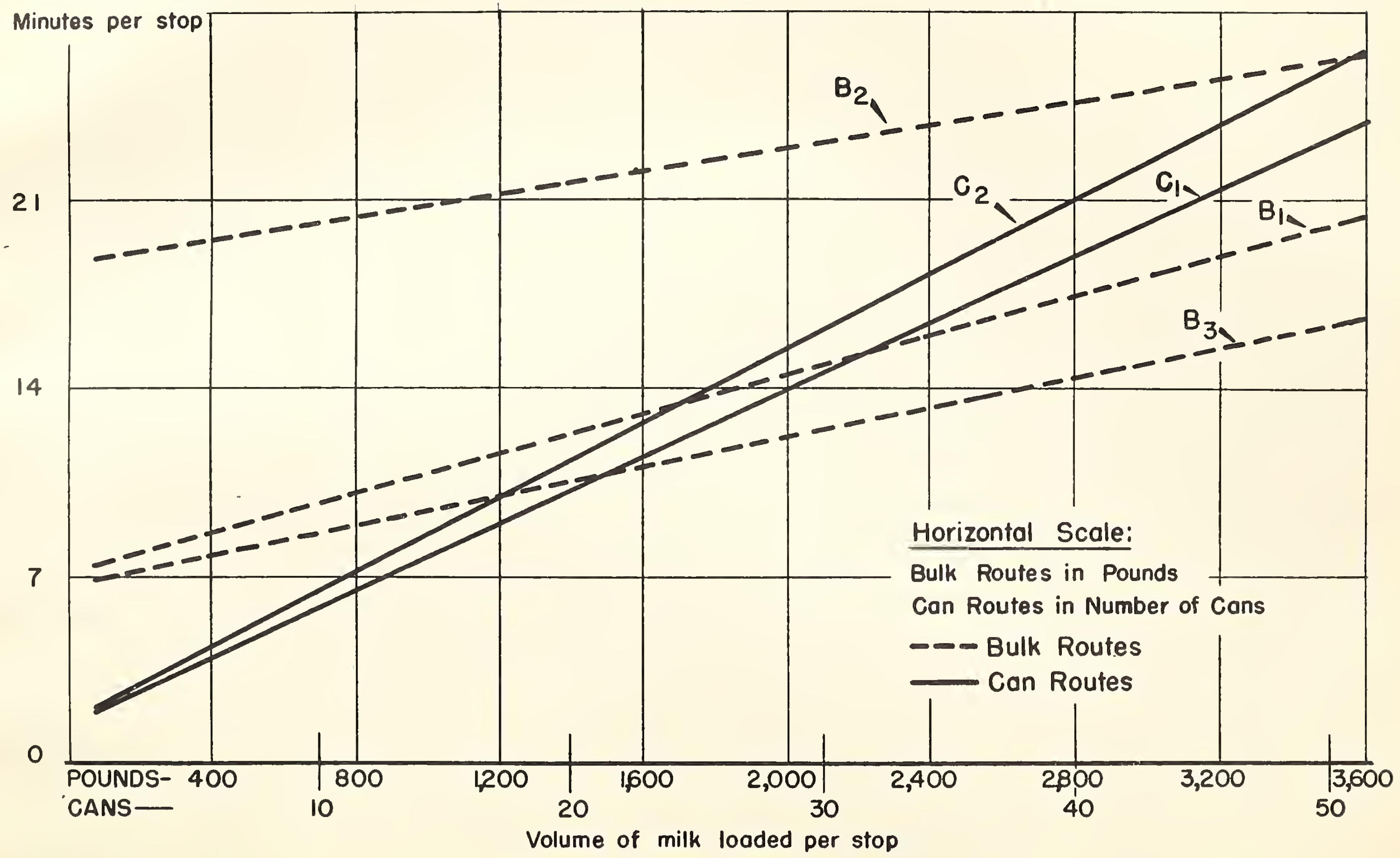
4/ Clark, D. A., Jr. A Comparative Analysis of the Costs of Operating Milk Collection Routes by Can and by Tank in California. Mime. Rpt. No. 91. pp. 18-24. Berkeley. 1947.

5/ The relationship between volume and time at the farm was derived statistically by the method of least squares. Time of the individual stop was correlated with volume of the individual stop. These relationships include both productive and non-productive time spent at the farm by the hauler. Regression equations and related information are shown in the appendix table 2.

6/ See reference cited in footnote 4.

Figure 1

Time Per Farm Stop Related to Volume of Milk or Number of Cans Loaded



The most important relationship, as shown in figure 1, was that between bulk routes and can routes. In all cases the farm stop time requirements on the bulk routes exceeded those on the can routes at volumes under 1,200 pounds per stop. At volumes in excess of 1,500 pounds the most efficient bulk route, B3, from the standpoint of farm stop time requirements, required less time per stop than the more efficient of the two can routes. Time requirements on the least efficient bulk route, B2, exceeded that of the least efficient can route until the 3,500 pounds per stop level was reached.

Other studies have shown comparatively high correlations between farm stop time and volume when only the productive farm stop time was considered. The average relationship between farm stop time and volume per stop as plotted in figure 1 was quite similar to that found in other studies. The degree of correlation, however, was very low and the time required for any individual farm stop often varied greatly from the average for all stops in the same volume range.

Such findings appear logical since the time actually spent at the farm by the hauler is affected by numerous factors other than the volume of milk handled. Among them were convenience of the milk house, delays due to milking not being completed when the truck arrives, occasional power failures, the inclination of the hauler to visit with producers, and similar factors not related to volume. These obviously caused much larger variation in the day-to-day farm stop time of both the can routes and bulk routes covered in this study than did factors related to volume.

Further statistical analyses were made relating average stop time for the various volume groups to the regression lines shown in figure 1. Such treatment of the data revealed that the relationships shown in figure 1 indicated with reasonable accuracy the average amount of time spent at the farm in relation to the volume of milk loaded. The relationships shown can be used to estimate the average time spent at all farms of any given volume over an extended period of time. Neither the time of any one particular stop nor the average time for a particular patron with a specified volume can be accurately estimated from these data, however.

The description of the actual operations of these routes was completed by the calculation of labor returns as summarized in table 5. Hauling rates used were the amounts actually paid to the hauler including subsidies paid by the receiving plants. One of the plants paid a 4 cents per hundredweight subsidy on Grade B can milk. The other paid a 1.5 cents subsidy likewise only on Grade B milk. In all cases, rates charged producers and paid haulers for hauling Grade A milk were identical.

Table 5. -- Average labor returns for bulk and can milk hauling

Item	Unit	Route number				
		B1	B2	B3	C1	C2
		Farm to plant operations				
Length of route	Miles	45.5	112.7	225.7	44.2	103.9
Truck operating costs per mile	Cents	16.20 1/	11.29	11.39	15.54	10.70
Average load	Pounds	12,200	11,683	11,350	6,491	8,417
Average rate paid hauler	Cents per cwt.	20.00	18.58	30.26	17.50	22.90
Hauler's gross income per trip	Dollars	24.42	21.70	34.34	11.36	19.27
Truck operating costs per trip	Dollars	7.37	12.72	25.70	6.87	11.12
Net to hauler	Dollars	17.05	8.98	8.64	4.49	8.15
Average time per trip	Hours	6.63	7.57	10.19	3.71	7.82
Net returns per hour	Dollars	2.57	1.19	.85	1.21	1.04
		Inter-plant operations				
Average length of trip	Miles	None	91.7	145.3	None	None
Average load	Pounds		12,112	13,893		
Rate per cwt.	Cents		10.23	16.00		
Hauler's gross income per trip	Dollars		12.39	22.23		
Truck operating cost per trip	Dollars		10.35	16.54		
Net to hauler	Dollars		2.04	5.69		
Average time per trip	Hours		3.8	5.0		
Net returns per hour	Dollars		.54	1.14		

1/ Does not include depreciation and interest on tank which is owned by the association.

Producers on bulk route B1 were paying 20 cents per hundredweight for hauling as compared to 17.5 cents when their milk was transported in cans. Hauling rates on the second bulk route were unchanged from previous can rates. They varied from 15 cents to 25 cents per hundredweight and averaged 19.4 cents. All producers on the third route paid 35 cents per hundredweight for bulk transportation to the central receiving plant. They had previously delivered milk to a receiving station with a 15 cents per hundredweight price differential under the central plant at a hauling cost 15 cents less than the current bulk rate. Their net transportation cost was thus unchanged. The average rates used on routes B2, and B3 in table 5 include lower rates for receiving station milk hauled on the regular runs and are thus lower than the producer rates cited above.

Truck operating costs used in this calculation were the costs on the individual trucks. Fixed costs were allocated on the basis of total service mileage of each truck during the 6 months period for which records were obtained.

Although the truck operating cost per mile on the short bulk route was greatly in excess of similar costs on other bulk routes, it returned the operator $2.57 per hour of operation as compared to $1.19 and 85 cents on the other routes. These differences in returns reflected much of the variations in inputs of time and mileage per hundredweight of milk as shown in table 4. Haulers' incomes per trip ranged from $4.49 to $17.05. The average time spent per trip ranged from 3.71 hours to 10.19 hours. It was clear that the hauling rates were not closely correlated with costs in terms of average time per trip.

The two trucks used in interplant operations had earnings of 54 cents and $1.14 per hour for the time spent in such operations. The over-the-road hauling rates in these two cases were closely correlated to the inputs of time and mileage per trip. Essentially all of the difference in net returns per hour was due to the fact that the truck with the higher net return hauled a 15 percent larger average load.

Labor returns on the two can routes were reasonably comparable at $1.21 and $1.04, the higher return being realized on the short route.

Adjusted Operations

In the actual operations of these routes inputs of time and mileage per hundredweight of milk transported in bulk were less than inputs on milk transported similar distances in cans. The routes, however, were not comparable particularly in size and location of patrons served. The average daily volume of bulk shippers was much larger than the average of can shippers and distances between can shippers were much less than distances between bulk shippers.

It has been shown, in other words, that the per hundredweight inputs of time and mileage on bulk routes serving large producers were less than on can routes of comparable length serving small producers. In order to accurately compare the costs of the two systems of hauling, however, time and mileage costs must be determined when producers of equal size and identical location are served.

Time relationships shown by the actual route operations were used to construct alternative can, daily bulk, and every-other-day bulk routes serving identical groups of patrons. For purposes of such comparisons we selected a can truck of 125 can capacity and a bulk truck equipped with a 1,500 gallon tank. These units are representative of units in common use on commercially operated routes in the midwest.

The selection of a bulk tank of greater capacity than the can truck with which it was compared is representative of the shift taking place. Can trucks are typically being replaced by bulk trucks of greater capacity, thus reducing the total number of trucks required to serve a given group of producers.

It was assumed in the construction of these synthetic routes that:

1. The average volume per patron per day was constant.

2. The distance between patrons was constant.

3. The trucks hauled a load of 80 percent of capacity, that is, 7,000 pounds and 10,500 pounds of milk on the can and bulk routes, respectively.

4. Both the distance of the pickup area from the plant and the amount of over-the-road driving per trip were constant.

5. The number of patrons served and the length of the pickup section of the route varied with the size of the load hauled and the frequency of collection.

6. All trucks travelled at the same rate of speed on the pickup section of the routes with stops equally spaced. All trucks on the "over-the-road" drive maintained somewhat higher but uniform speed.

7. Time of farm stops was based on the average of the two more efficient bulk routes and the two can routes for which time records were obtained. Formulas used were:

   Farm stop time in minutes

   Bulk routes = 6.8n + .35 per hundredweight of milk
   Can routes = 1.45n + .46 per can
   When n = number of producers served.

8. Time at the plant -- 58 minutes for can trucks and 100 minutes for bulk trucks -- was derived from adjusted data of actual operations.

9. Time on the can routes was charged at the rate of $1.35 per hour as compared to $1.50 per hour on the bulk trucks. This differential was in recognition of the need for trained operators who must assume greater responsibilities on the bulk routes than on the can routes.

10. Mileage inputs were converted to dollar costs at rates varying with the annual mileage of the truck. Variable truck operating costs of 8 cents per mile were used for all trucks. Fixed annual costs of $2,032 and $1,125 have been used for bulk and can trucks, respectively. In calculating fixed costs per mile, it was assumed that the can trucks made 1 trip a day and the bulk trucks 2 trips a day.

These assumptions are self-explanatory with the possible exception of those regarding variation in number of producers and size of the procurement area served by the different types of routes. The analysis was not a comparison of hauling operations and costs when the same amount of milk was hauled equal distances by different methods. It was an estimate of before and after costs when a tank truck of typical size replaced a common sized can truck.

Since we assumed that the same type of producers must be served -- producers with equal average volume and equal spacing on the route -- the larger bulk truck obtained its load by covering a larger area and serving more producers than the can truck. The bulk truck had a 50 percent higher capacity than the can truck, served 50 percent more producers per trip and covered a proportionally larger procurement area. When operated on an every-other-day service basis, the bulk truck served only half as many producers and covered half as large a pickup area per trip as the daily bulk truck. Two bulk trucks thus replaced 3 can trucks, when operated on a 1 trip per day basis. If the bulk trucks operated on a 2 trip per day basis, as assumed in our analysis, each bulk truck replaced 3 can trucks.

The savings in total truck mileage required to serve a given area when bulk trucks replace can trucks depend to a large extent on the frequency of pickup service for the individual producer. Use of bulk trucks of the same size as the can truck replaced on a daily pickup service basis results in no savings in mileage. Use of bulk trucks of 50 percent greater capacity than the can trucks results in a saving of about one-third of the "over-the-road" mileage. They make fewer trips to and from the procurement area to haul a given volume of milk. When operated on an every-other-day service basis, use of the larger bulk trucks results in a savings in the over-the-road mileage plus up to 50 percent of the pickup mileage.

Mileage requirements of the alternative methods of procurement in a hypothetical area are diagrammed in figure 2.

For this illustration it was assumed that each of 3 can trucks served a 5 mile square area and drove 40 miles a day within the area served. The procurement area was assumed to be 15 miles from the milk receiving plant.

Daily mileages driven by the can trucks were as follows:

	Truck Number			
	1	2	3	Total
Area served	C1	C2	C3	-
Mileage: pickup area	40	40	40	120
Over the road	35	30	35	100
Total	75	70	75	220

When the 3 can trucks were replaced by 2 bulk trucks or by 1 bulk truck making 2 trips per day and rendering daily pickup service to all producers in the area, the daily mileages as calculated from figure 2 were as follows:

	Trip 1	Trip 2	Total
Area served	ABIH	HICD	100 percent
Mileage: pickup area	60	60	120
Over the road	35	30	65
Total	95	90	185

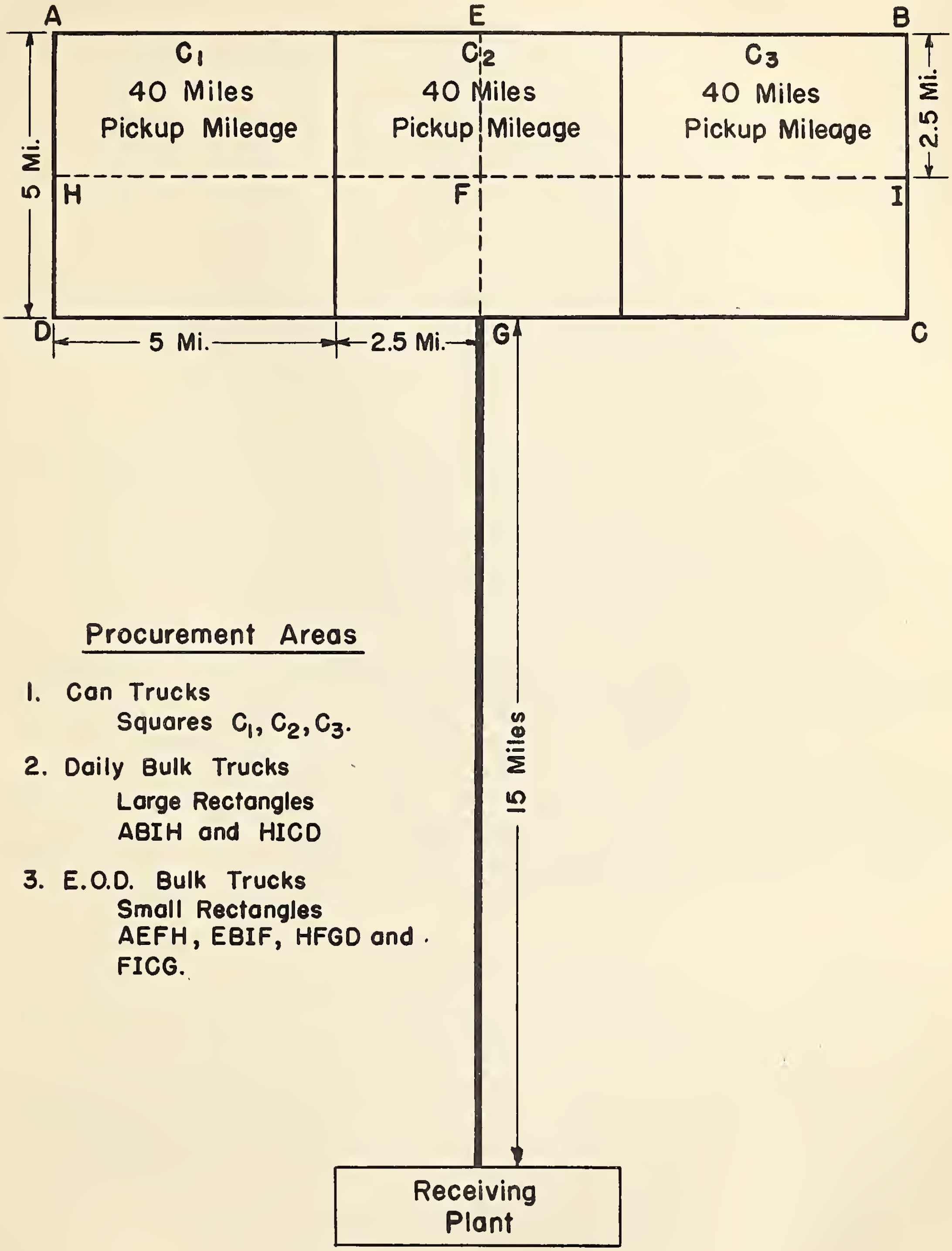
When the area was served by 2 bulk trucks or by 1 bulk truck making 2 trips per day, on an every-other-day service basis the mileages driven per day were:

	Trip 1	Trip 2	Total
Area served	EBIF	FICG	50 percent
Mileage: pickup area	30	30	60
Over the road	35	30	65
Total	65	60	125

On alternate days the E.O.D. bulk truck would serve areas AEFH and HFGD with the same daily mileage.

Figure 2

Hypothetical Milk Procurement Area Served Alternatively by Can and Bulk Trucks



Savings in truck mileage when the 3 alternative methods were applied under the conditions assumed in this case were summarized as follows:

	Daily mileages			Reduction from can route mileage on	
	Can routes	Daily bulk routes	E.O.D. bulk routes	Daily bulk routes	E.O.D. bulk routes
Pickup	120	120	60	0	60
Over the road	100	65	65	35	35
Total	220	185	125	35	95

Reductions in the total over-the-road mileage were generally in proportion to reductions in number of trips to and from the area. The over-the-road mileage per trip remained relatively unchanged. In constructing synthetic routes in subsequent tables equal over-the-road mileages per trip for each of the 3 methods of procurement were used.

In the example outlined above, the daily bulk trucks with larger capacity required fewer trips to cover the area. The result was a reduction of 35 miles in the over-the-road mileage driven daily. Since they served the same producers as the can trucks, no savings in the total daily pickup mileage resulted. The total reduction resulting from utilization of the daily bulk truck was thus 35 percent of the "over-the-road" mileage or 16 percent of the total mileage of the can trucks replaced.

Mileage savings in the case of E.O.D. service by bulk trucks is much more significant, however. Since producers hold their milk for 2 days the E.O.D. bulk trucks serve only half as large an area to obtain the same amount of milk as the bulk trucks rendering daily service. Only 50 percent of the total procurement area is served each day. Thus, in addition to the savings in over-the-road mileage from daily bulk operations, an additional saving of up to 50 percent of the pickup mileage results from E.O.D. bulk operations. In this illustration E.O.D. bulk hauling actually saved 95 miles per day or 43 percent of the total can route mileage required to serve the area.

A note of caution appears advisable at this point. The 50 percent reduction of pickup mileage as illustrated above in the case of E.O.D. bulk operations is a maximum. It was based on the assumption of perfect divisibility of the pickup area, that is, half the producers in the area could be served by E.O.D. bulk tank with half of the pickup mileage required to serve the entire area by can truck. In theory, savings of up to 50 percent of the procurement area mileage are possible but the percentage actually realized in practice will vary with the topography of the route and the layout of serviceable roads in the area. Under actual conditions the savings on many routes will be substantially less than 50 percent. On a straight line route, for example, which lies along one road, the savings of mileage on pickup area roads would be only 37.5 percent when the capacity of the bulk truck is 50 percent in excess of that of the can truck replaced.

Table 6 shows a comparison of can, daily bulk, and E.O.D. bulk milk hauling costs on a relatively short route serving large patrons. These results were obtained by applying the assumptions detailed on pages 22 and 23 to patrons with the same average volume and location relative to each other and to the receiving plant, as the patrons actually serviced by the shortest of the three bulk routes (table 2).

On this route producers averaged 836 pounds of milk per day. The distance between producers was 2.2 miles and the pickup area was approximately 7 miles from the receiving plant. These factors were held constant regardless of the type of hauling operation. The number of patrons served each trip and the length of the pickup section of the route varied in accordance with the size of the load hauled and the frequency of pickup service as previously discussed.

On the basis of cost conversion factors used in this analysis, E.O.D. bulk hauling in this case yielded a savings of 3.93 cents per hundredweight of milk hauled as compared to can hauling costs under the same conditions. Daily bulk hauling was only 0.83 cents per hundredweight less costly than can hauling even with the relatively high production per patron existing on this route. The advantage of E.O.D. bulk service as compared to daily can pickup was apparent in both time and mileage costs.

Total time requirements on the E.O.D. bulk route were 2.52 minutes per hundredweight of milk as compared to 3.28 and 3.05 minutes on the daily bulk and can routes, respectively. Time savings on the E.O.D. bulk route were traced to two primary sources -- less travel time and less farm stop time per hundredweight than for either of the other methods of operation. On the daily bulk route, lower unit travel time requirements were more than offset by higher farm stop time requirements.

It was clear in this case that the primary reduction in hauling cost was in mileage. The E.O.D. bulk route traveled only .26 of a mile per hundredweight of milk hauled as compared to .40 and .46 miles on the daily bulk and can routes, respectively. Per hundredweight mileage costs on the E.O.D. bulk route were 1.2 cents lower than on the daily bulk route and 3.37 cents less than on the can route.

It is important to realize, however, that the savings in mileage cost, on this short route, were to a large extent dependent on fuller utilization of the higher cost bulk truck than of the can truck. As previously indicated the mileage costs used in this calculation were based on 2 trips a day for the bulk trucks as compared to 1 trip for the can truck. If we assume that the bulk trucks make only 1 trip a day, overhead operating cost per mile and per hundredweight of milk increase substantially. The per hundredweight increase is approximately 2.6 cents. On short routes -- similar to the one illustrated in table 6 -- such an increase in mileage costs alters the relative advantage of bulk hauling operations significantly. Daily bulk service becomes somewhat more costly than can hauling service and the net advantage of E.O.D. bulk service is reduced to less than 1.4 cents per hundredweight.

Table 6. -- Bulk and can milk hauling costs compared on a short route serving large patrons 1/

Item	Unit	Type of route					
		Daily can		Daily bulk		E.O.D. bulk	
Production per patron per day	Pounds	836		836		836	
Distance between producers	Miles	2.2		2.2		2.2	
Milk load hauled	Pounds	7,000		10,500		10,500	
Number patrons served	Number	8.4		12.6		6.3	
Length of route							
Over-the-road	Miles	13.9		13.9		13.9	
Pickup section	Miles	18.5		27.7		13.9	
Total	Miles		32.4		41.6		27.8
Time requirements							
Travel over-the-road	Minutes	27.8		27.8		27.8	
Travel between patrons	Minutes	49.6		74.2		37.1	
Total travel time	Minutes	77.4		102.0		64.9	
Stop time							
At farms	Minutes	58.2		122.4		79.6	
At plant	Minutes	58.0		100.0		100.0	
Other	Minutes	20.0		20.0		20.0	
Total stop time	Minutes	136.2		242.4		199.6	
Total time	Minutes		213.6		344.4		264.5
Labor and truck operating costs							
Time per cwt. of milk	Minutes	3.05		3.28		2.52	
Labor rate per minute	Cents	2.25		2.50		2.50	
Labor cost per cwt. of milk	Cents		6.86		8.20		6.30
Miles per cwt. of milk	Miles	.46		.40		.26	
Truck operating cost per mile	Cents	17.5		14.7		18.0	
Truck operating cost per cwt. of milk	Cents		8.05		5.88		4.68
Total hauling costs per cwt.	Cents		14.91		14.08		10.98

1/ Constants: Production per patron per day and density of patrons on route.
Variables: Number of patrons served per trip and length of route.

Bulk trucks had high fixed costs as compared to the can trucks. This necessitates fuller utilization of bulk trucks if comparable per mile costs of operation are to be attained. Two trips daily per truck appears the logical way of spreading the high overhead, particularly when routes are relatively short. Can haulers may also reduce their unit overhead costs by hauling 2 loads a day. This practice is relatively uncommon, however, due to less flexibility in can milk receiving operations than in bulk milk receiving operations. Higher labor requirements in receiving can milk make it more difficult to extend the hours during which milk in cans is received at the plant. Lower labor requirements associated with bulk receiving make "odd hour" receiving of bulk milk more practicable.

The inputs of time and mileage for the various systems of procurement on similar routes based on each of the original routes are tabulated in table 7. Further details of the constructed routes are shown in the appendix table 3. These results were derived by applying the assumptions and methods illustrated for the one route in table 6.

Production per patron per day, the distance between patrons in the procurement area and the distance of the procurement area from the plant were held constant for each of the three types of routes -- daily can, daily bulk, and E.O.D. bulk. Vertical comparisons in this table thus show results of the various types of route operation when the above influential factors are equal. Several significant facts can be observed in these data. First the routes represented a rather wide range of conditions. Average production per patron per day ranged from 375 pounds to over 1,100 pounds. The average distance between patrons in the procurement area varied from 1 to 10 miles. The distance of the procurement area from the receiving plant ranged from 7 to 63.5 miles.

In spite of the wide range in conditions represented, one constant relationship may be observed. In each of the 7 cases the inputs of time and mileage and the cost of hauling per hundredweight of milk on the every-other-day bulk route were less than on either daily bulk or can routes serving the same patrons.

It will be noted, however, that although E.O.D. bulk procurement always showed an advantage, the degree of advantage varied greatly between routes. On route B1, for example, the time advantage over the can route was only .53 minutes per hundredweight as compared to 2.65 minutes on route B3. The advantage in miles per hundredweight on these same routes was .2 and 1.7 miles, respectively. In terms of cost per hundredweight, E.O.D. bulk showed an advantage of less than 4 cents on route B1 as compared to approximately 17.2 cents on route B3.

Table 7. -- Bulk and can milk hauling costs compared for 7 routes 1/

Item	Unit	Model route number						
		B1	B2	B3	C1	C2	B1 + C1	B2 + C2
Production per patron per day	Pounds	836	1,112	458	375	377	586	706
Distance between producers	Miles	2.2	8.5	10.0	1.7	2.4	1.0	2.0
Distance pickup area to plant	Miles	7.0	35.7	63.5	7.2	24.7	7.0	24.7
		Minutes per cwt. of milk						
Time requirements								
On daily can route		3.05	5.11	8.66	3.81	5.00	3.09	4.18
On daily bulk route		3.28	4.70	8.61	4.80	5.68	3.60	4.21
On E.O.D. bulk route		2.52	3.70	6.01	3.28	4.04	2.68	3.30
		Miles per cwt. of milk						
Mileage requirements								
On daily can route		.46	1.79	4.00	.67	1.36	.37	.99
On daily bulk route		.40	1.45	3.40	.60	1.12	.30	.76
On E.O.D. bulk route		.26	1.06	2.30	.37	.79	.22	.61
		Cents per cwt. of milk						
Hauling costs								
On daily can route		14.91	30.21	55.89	18.35	26.48	14.35	21.68
On daily bulk route		14.08	25.96	54.16	19.50	25.85	14.04	19.27
On E.O.D. bulk route		10.98	20.35	38.72	13.86	19.03	11.14	15.75

1/ Density of patronage on the route and production per day are constant. Based on loads of 7,000 pounds and 10,500 pounds on can and bulk trucks, respectively.

When daily bulk routes were compared with can routes serving the same patrons, the relationship was less consistent. In each case the daily bulk route required less miles per hundredweight of milk than the can route. This was a direct result of the larger load hauled over the "over-the-road" section of the route. In unit time requirements, however, the can routes in most of these cases had an advantage over the daily bulk route. On route C1, can hauling cost was less than daily bulk costs while on the others the reverse was true.

Note that the advantages of E.O.D. bulk delivery were greatest on the longest route (B3) and least on the shortest route (B1). It was also apparent that time requirements per hundredweight of milk on daily bulk routes exceeded those on can routes except when the routes were long. When routes were short and the volume per patron small, the unit time requirements on daily bulk routes were substantially in excess of those on can routes serving the same class of patrons. Daily bulk hauling resulted in a substantial saving (4.25 cents) on B2 with the larger patrons, while on B3, the longer route with smaller patrons, the savings were only 1.73 cents per hundredweight.

It was thus apparent that variations between costs of hauling in cans and in bulk were closely related to the volume of production per patron and the length of the route. Before proceeding with such an analysis, however, attention was directed to facts reported in the 2 columns to the right of table 7. As indicated earlier in this report, bulk route B1 and can route C1 covered different patrons in the same area. The same was true of routes B2 and C2. In the 2 right hand columns, cost factors were estimated for can and bulk routes serving average patrons in each of these 2 areas. In the first area, B1 plus C1, E.O.D. bulk hauling on a route composed of the average of all patrons was slightly more costly than it was on the original route, B1, serving only the larger patrons. Costs to the smaller patrons, however, were reduced substantially by such a combination. In this case, where the original bulk route was short and relatively compact, savings in mileage resulting from the combination were more than offset by higher unit time requirements of the smaller patrons.

In the second case, B2 plus C2, both the large and the small patrons benefited by the combination. The large patrons on route B2 reduced their hauling costs by combining with the smaller producers in their immediate vicinity instead of with other large producers scattered as they were on the actual route. In each of these cases the combination resulted in a reduction of the average cost of hauling for all milk. The cents per hundredweight advantage of bulk hauling as compared to can hauling was reduced, however, as compared to the advantage on the original routes. The combined route was naturally a shorter route than either of 2 routes, one serving the large patrons in the area and the other serving the smaller patrons.

FACTORS AFFECTING COMPARATIVE COST RELATIONSHIP

The relationship between bulk and can hauling cost is directly affected by the length of the route and by variations in the volume per farm and per route. The effects of each of these cost factors, when other conditions affecting cost are constant, are examined in this section of the report.

Volume Per Patron

Comparing can and bulk milk hauling costs on individual routes showed variations in costs between the various systems of hauling were related to those in the average daily volume per patron served. The nature of this relationship is presented graphically in figure 3. In order to exclude the effects of other factors on costs, we held route length and route volume constant for each type of route as indicated. The comparison was thus between a can truck hauling a 7,000 pound load and bulk trucks hauling a 10,500 pound load, each covering sufficient pickup area to obtain the load specified.

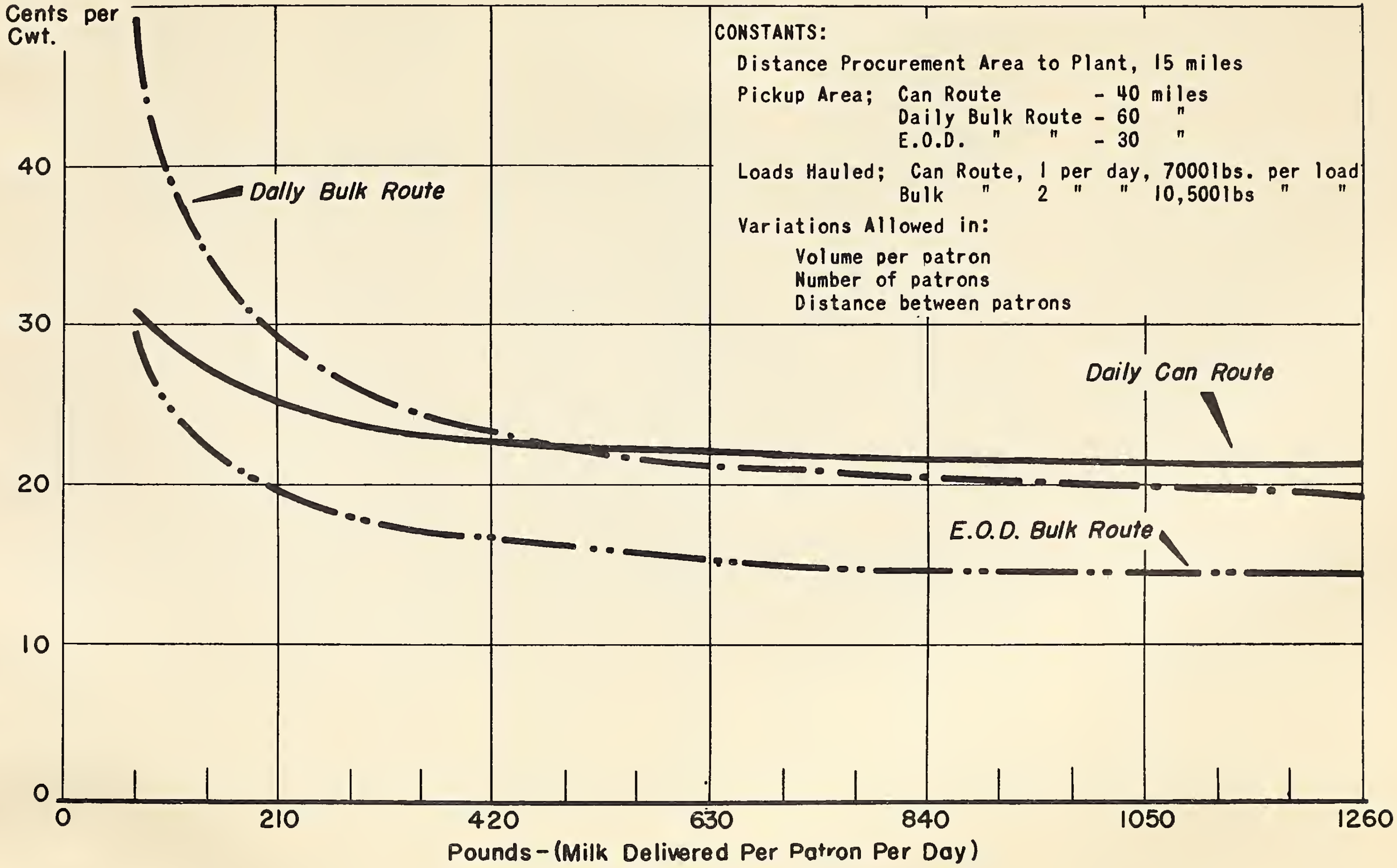
Under these conditions the can truck traveled 1 mile for each hundredweight of milk hauled as compared to .86 miles and .57 miles on the daily bulk and E.O.D. bulk routes, respectively. Truck operating costs were 12.4 cents per hundredweight of milk hauled on the can route as compared to 9.55 cents on the daily bulk route and 7.18 cents on the E.O.D. bulk route. Since the length of the route and the size of the load did not vary for each truck, its operating cost per hundredweight of milk was constant, irrespective of the size and number of patrons served. If no other factors were affecting costs as the volume per producer increased, can hauling costs would maintain a constant differential 2.85 cents higher than daily bulk costs and 5.22 cents higher than E.O.D. hauling costs.

Figure 3 indicates, however, that no such consistent relationship existed between hauling costs on the various types of routes. As the volume per patron per day increased, the relationship between bulk and can hauling cost changed significantly. At the bottom of the volume range, can hauling costs were much lower than daily bulk and only slightly higher than E.O.D. bulk hauling costs. As volume per patron increased, however, total unit costs on the bulk routes dropped much faster than on the can route. The cost advantage of E.O.D. bulk hauling increased rapidly as production per patron increased to about 500 pounds per day and slowly thereafter.

Daily bulk hauling costs exceeded can hauling costs until production per patron per day reached the 500-pound level. At higher levels of production daily bulk hauling had a slightly increasing cost advantage. The cost advantage of daily bulk hauling over can hauling in this case was entirely dependent upon fuller utilization of the bulk truck. The mileage costs in this comparison were calculated on the basis of two trips a day by all bulk trucks. If costs on the daily bulk route were calculated on the basis of one trip a day, they would not drop below can hauling costs within the volume range of the chart.

Figure 3

Costs of Can and Bulk Milk Hauling Related to Volume Per Patron Served



Although the cost advantage of every-other-day bulk hauling increased slightly as volume per patron increased, patrons did not need to be exceptionally large to realize a substantial part of the potential savings in hauling costs. When patrons averaged 350 pounds of milk a day, can hauling costs were 23.11 cents as compared to 17.41 cents on the E.O.D. bulk route. If the patrons averaged 700 pounds a day, all other factors remaining the same, costs became 21.87 cents and 15.28 cents on the can and E.O.D. bulk routes, respectively. The E.O.D. advantage for the 350 pound patrons was thus 5.70 cents as compared to 6.59 cents for the 700 pound producers. At the 1,400 pound per day production level the advantage of E.O.D. bulk was only 6.8 cents per hundredweight.

The changing relationship between bulk and can hauling costs, as the volume of production per patron per day increased, was due to variations in the rate of change in unit time requirements. Figure 4 shows total per hundredweight time requirements of the routes depicted in figure 3. The relationship between these unit time curves was similar to the relationship between the total cost curves. The total time reqirements on the daily bulk route, however, did not drop below those of the can route. At higher volume levels, slightly higher time costs on the daily bulk route were offset by lower unit truck operating costs and total costs fell below those on a can route of comparable length and density of patronage.

Due to additional functions performed, the unit farm stop time requirements at small volumes were much higher for bulk procurement than for can procurement. As shown in figure 5, the difference in per unit stop time requirements between the various methods of hauling diminished rapidly, but at a decreasing rate, as the volume per patron increased. If daily bulk service were to be given producers averaging 70 pounds per day, the truck would spend approximately 10 minutes per hundredweight of milk at the farm. The E.O.D. bulk truck and the can truck would spend 5.2 and 2.73 minutes per hundredweight, respectively, at the farm for the same volume.

At the other end of the volume scale, (figure 5) there was relatively little difference in the stop time requirements on a hundredweight basis. The E.O.D. bulk route curve crosses the can route curve at 630 pounds but the daily bulk route curve is still slightly higher at the 1,260 pound level of production. At higher volumes the change in relationship between the daily bulk and can route curves was slight and they did not cross until a volume of 1,745 pounds per day was reached.

The advantage of bulk hauling in relation to can hauling was influenced by the size of the producers served. Bulk procurement costs on either daily or E.O.D. routes dropped faster than on daily can routes as the volume per producer per day was increased. In other words, potential reductions in hauling costs on routes composed of large patrons were greater than on routes of equal length serving smaller patrons. The rate of gain in E.O.D. bulk hauling costs compared to can hauling costs was slight when volume per producer per day exceeded 500 pounds. A large part of the advantages of E.O.D. bulk hauling were reflected in reduced costs at the 350 pounds per day or average patron level.

Figure 4

Total Hauling Time Requirements Related to Size of Patrons Served

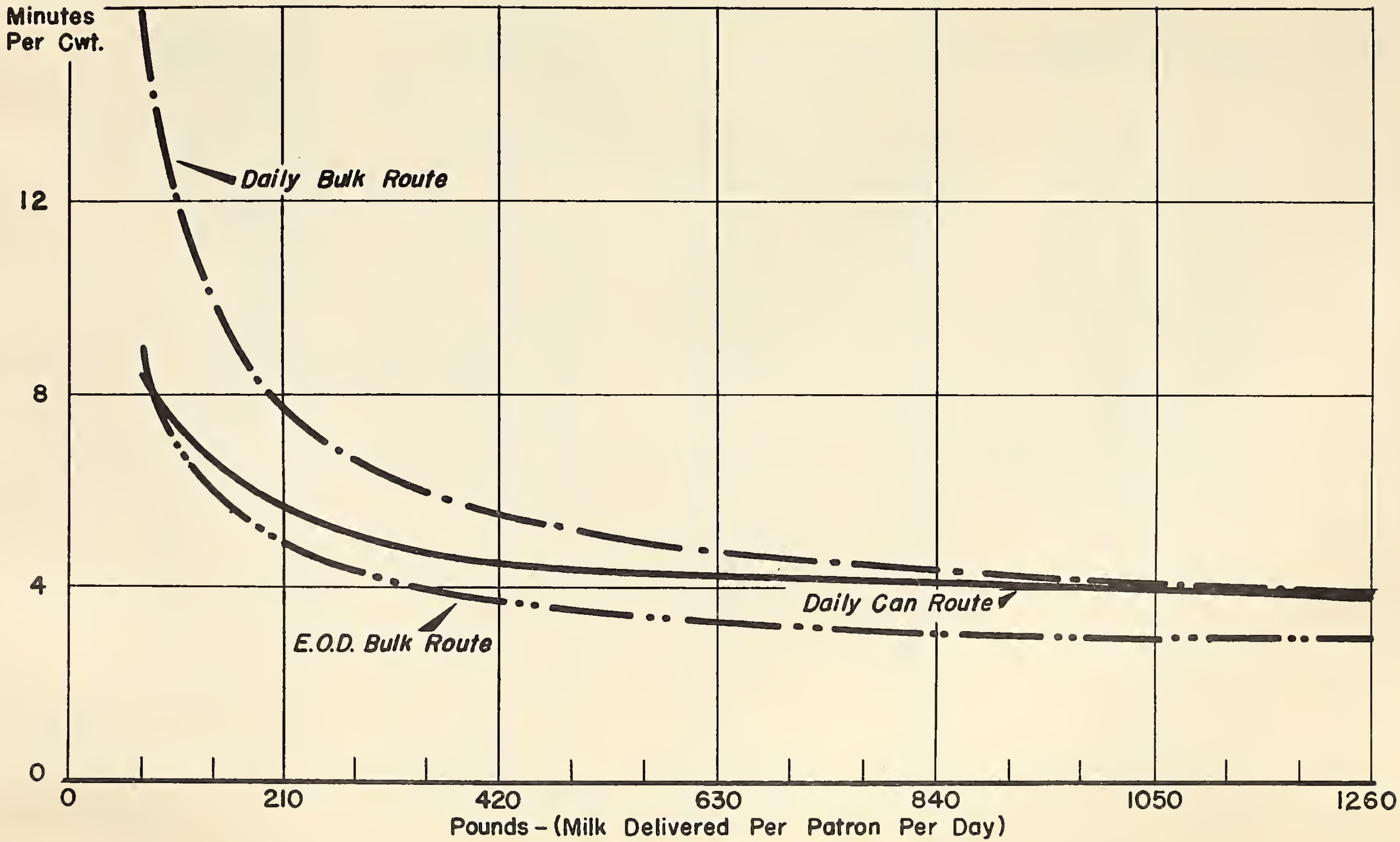
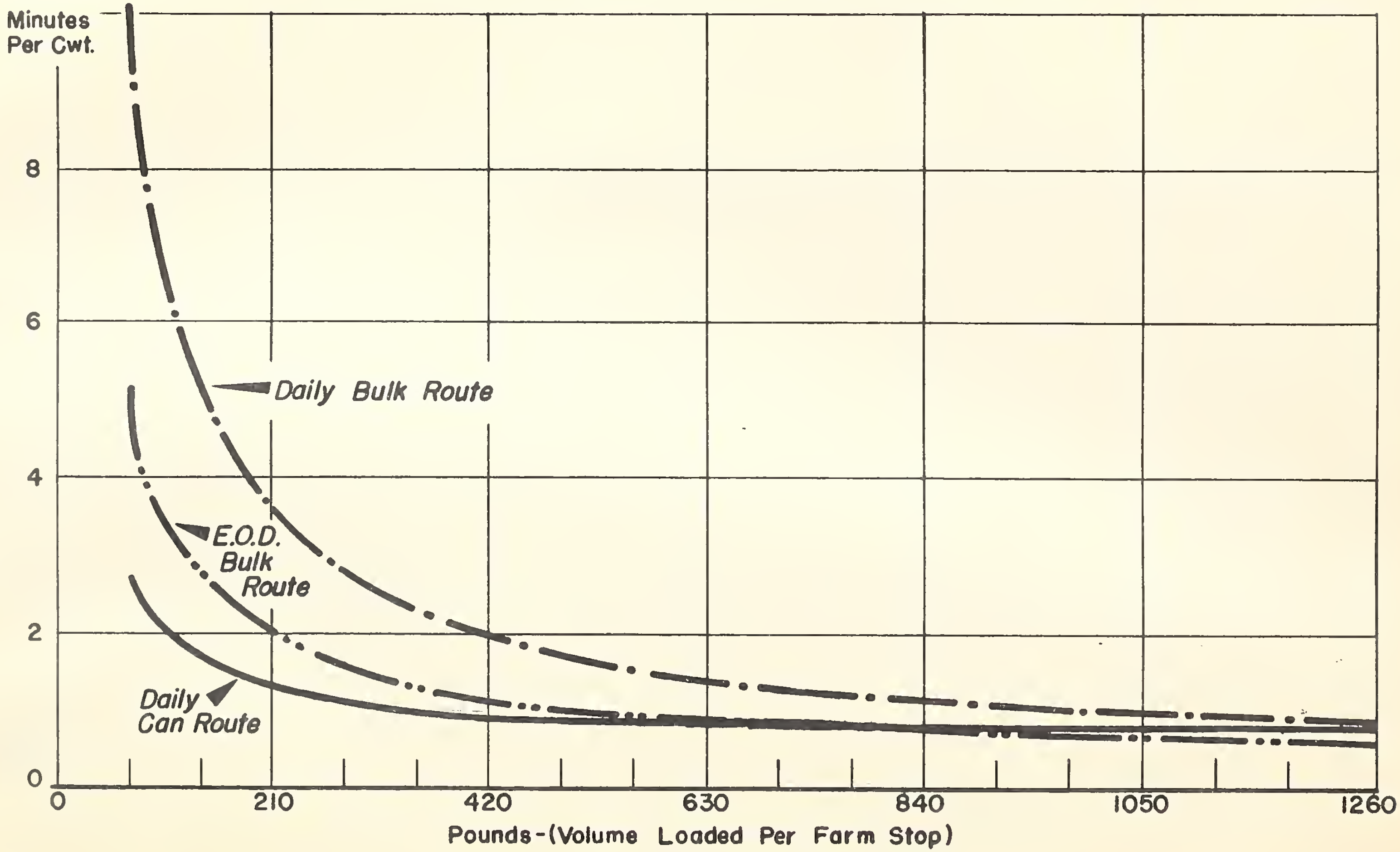


Figure 5

Unit Farm Stop Time Related to Volume of Milk Loaded Per Stop



On a route of average length, daily bulk hauling can be expected to result in only slight reductions in hauling costs even when the average daily production per patron is large.

Thus this study showed the basic advantage in bulk hauling, as generally practiced, is a reduction of mileage per hundredweight of milk hauled. This economy results from larger loads and less frequent pickup service. When daily service is rendered on the bulk route, relatively high farm stop time requirements offset all or a substantial part of the economy in mileage unless producers served are exceptionally large. E.O.D. service on the bulk route doubles the volume of milk loaded per stop and eliminates most of the time cost disadvantage.

Length of Route

The cost advantage of bulk hauling as compared to can hauling increased as the length of the route increased. The distance which must be driven to obtain a specified size load of milk depended upon the location of the procurement area relative to the receiving plant and the density of patronage within the procurement area.

The effect on hauling costs of variations in the location of the procurement area relative to the plant is shown in figure 6. When the pickup section of the route started and ended at a point 5 miles from the plant, hauling costs on a 7,000 pound can route were 19.5 cents as compared to 21.9 cents and 15 cents on the daily bulk and E.O.D. bulk routes each hauling a 10,500 pound load.

Costs on the can route, at conversion rates used in this analysis, increased at the rate of 3.6 cents per hundredweight for each additional 10 miles added to the procurement radius (or 20 miles added to the length of the route). Costs on the bulk routes, daily and E.O.D., however, increased only at the rate of 2.45 cents per hundredweight for an equal increase in the length of the route. Hauling costs on the bulk routes thus improved relative to costs on the can route at the rate of 1.15 cents per hundredweight of milk hauled for each increase of 10 miles in the distance between the procurement area and the receiving plant.

The economy in this case was entirely one of size of load. The cost of driving an additional 20 miles was added to the gross cost of operating the route. On the can route this additional cost was spread over 7,000 pounds of milk -- on the bulk routes over 10,500 pounds. Costs on the daily and E.O.D. bulk routes, with equal loads, maintained the same differences irrespective of the distance of the procurement area from the plant. If a similar comparison were made, assuming that the can truck hauled a load equal to that of the bulk trucks, there would be no change in the relationship of bulk and can hauling costs as the distance to the procurement area increased or decreased.

Figure 6
Distance Between Procurement Area and Receiving Plant Related to Hauling Costs on Can and Bulk Routes

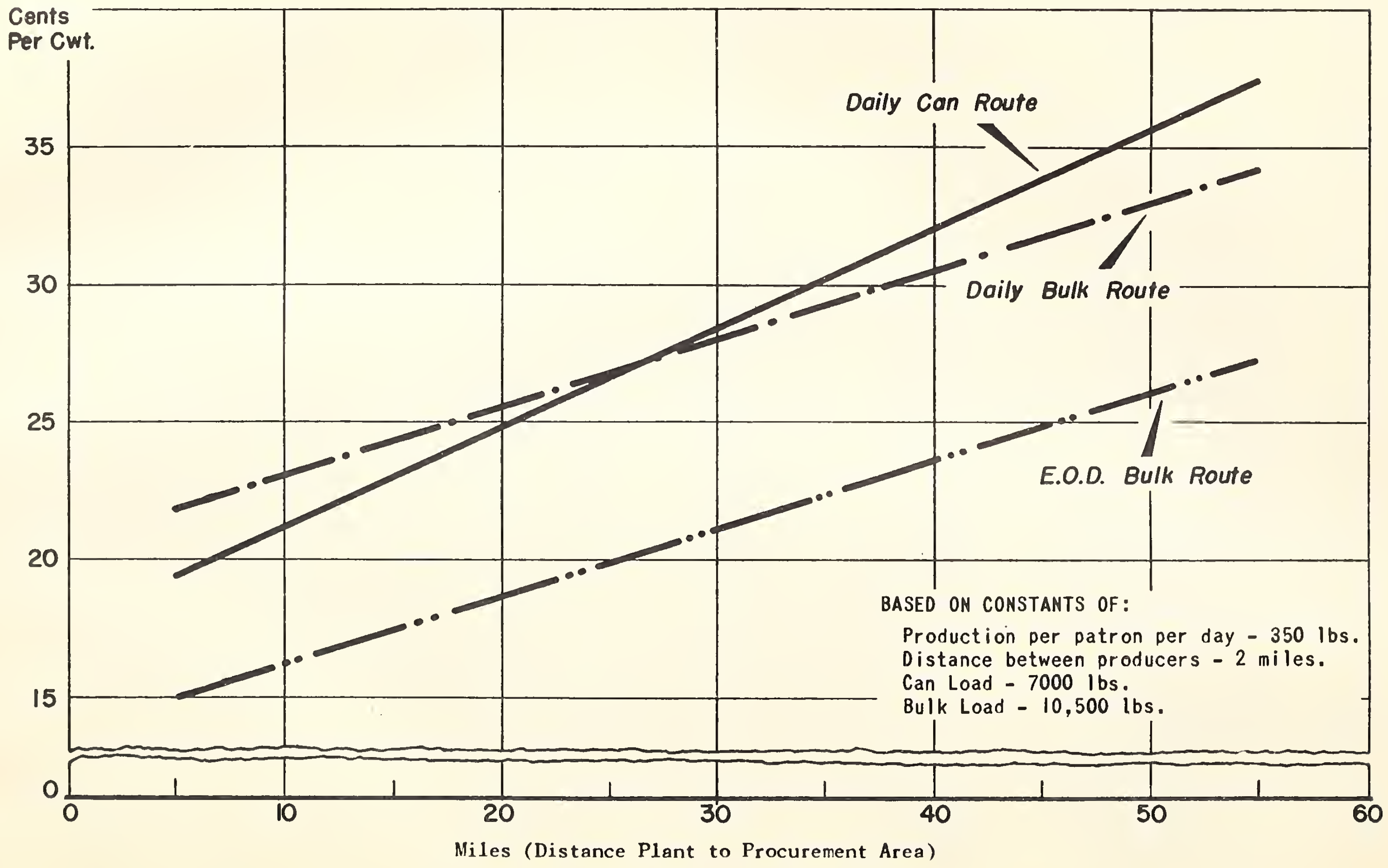


Figure 6 illustrates another significant fact. The relationship of daily bulk hauling costs to can hauling changed from a disadvantage to an advantage. When the procurement area was less than approximately 27 miles from the plant, can hauling costs were slightly below daily bulk hauling costs for patrons averaging 350 pounds per day. At greater distances the positions were reversed. When the procurement area was relatively near to the plant, economies arising from the larger bulk truck load on the over-the-road segment of the route were insufficient to entirely offset the higher loading time requirements associated with the daily bulk method of operation.

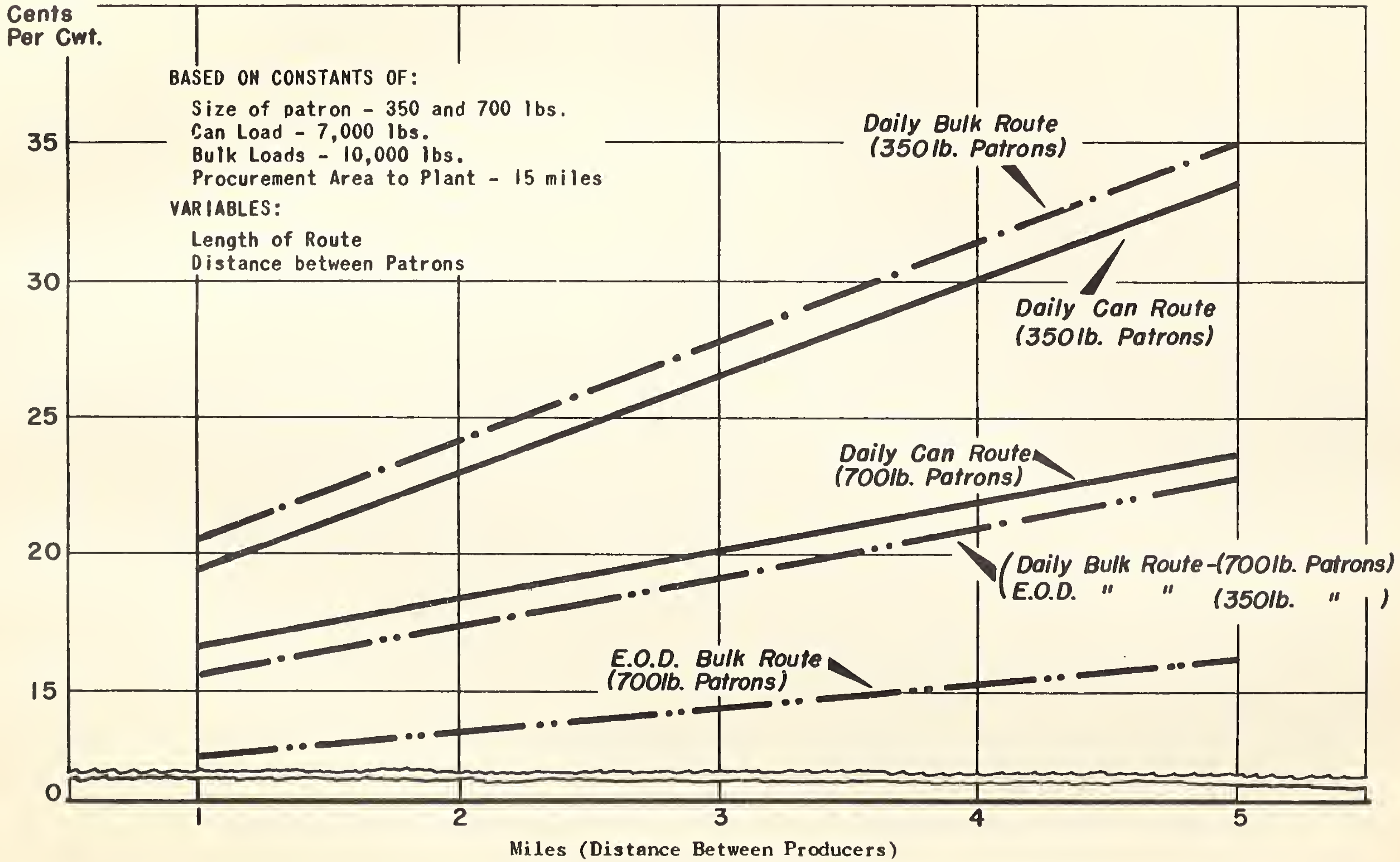
When the length of a route was increased because of variations in the density of patronage in the procurement area the effect on the relationship between can, daily bulk, and E.O.D. bulk hauling costs was significantly different than when the increased length of route was due to remoteness from the receiving plant.

The solid lines in figure 7 indicate the changing relationship between costs of the various methods of hauling milk of producers averaging 350 pounds of milk per day as patronage became less and less dense. An increase of one mile in the average distance between producers in the pickup area resulted in an increase of approximately 3.5 cents per hundredweight in the cost of hauling on the daily can and daily bulk routes. The comparable increase on the E.O.D. bulk route is 1.8 cents.

The dotted lines indicate the same relationship for patrons averaging 700 pounds per day. In this case, the rates of increase in costs are 1.75 cents per hundredweight and 0.9 cents per hundredweight for each mile increase in the distance between patrons. There is an inverse relationship between the size of the patrons served and the rate of increase in costs as the distance between patrons increases.

Equal increases in the distance between patrons added mileage to the daily can and daily bulk routes proportionate to the size of load hauled. A constant difference between hauling costs on such routes was thus maintained, irrespective of the distance between producers. A decrease in the density of patronage, however, added only 50 percent as much mileage to an E.O.D. bulk route as to the other types of routes. For example, when 350 pound producers are 1 mile apart the daily bulk route travels 30 pickup miles to serve 30 patrons per trip. An increase of 1 mile per patron increased the distance traveled to obtain the 10,500 pound load by 30 miles. The E.O.D. bulk route by comparison served only 15 patrons per trip. An increase of 1 mile per patron per trip thus added only 15 miles to the distance necessary to obtain a 10,500 pound load.

Figure 7
Density of Patronage Related to Hauling Costs, on Bulk and Can Routes


BASED ON CONSTANTS OF:
Size of patron - 350 and 700 lbs.
Can Load - 7,000 lbs.
Bulk Loads - 10,000 lbs.
Procurement Area to Plant - 15 miles

VARIABLES:
Length of Route
Distance between Patrons

Another interesting observation can be made on the basis of the relationships plotted in figure 7. The cost of hauling on the 350 pound can route when patrons are 1 mile apart was 19.5 cents. The cost on the 350 pound E.O.D. bulk route did not reach this level until the patrons are approximately 3.2 miles apart. In other words, the E.O.D. bulk truck could serve 1 out of 3 patrons served by the can truck route, increasing the length of the route accordingly, before the additional cost of the extra mileage will entirely offset the other economies of E.O.D. operations.

The contrast in this respect was even greater when larger patrons were involved. The cost on the 700 pound can route with patrons at intervals of 1 mile was 16.7 cents per hundredweight. The 700 pound E.O.D. bulk route cost line did not reach this level until patrons were approximately 5.5 miles apart.

The added distances the bulk truck can travel at the same per hundredweight cost as the can route will vary with other factors such as size of load, distance from procurement area to plant and rates charged for labor and truck operating costs. The cost relationships indicated in this particular example, however, go far in explaining how haulers can afford to haul milk from large scattered bulk patrons at the same or lower rates than they formerly charged on shorter can routes. The potential economies of E.O.D. bulk hauling in the early stages of bulk route development are being dissipated to a considerable extent by the necessity of serving scattered patronage. E.O.D. bulk routes serving all the patrons can result in significant reductions in hauling rates to producers -- while E.O.D. routes serving part of the patrons will absorb all or part of the potential savings by traveling extra miles to obtain a load.

Route Volume

We have shown that the cost advantage of E.O.D. bulk hauling over can hauling increased when the length of the route increased, other factors remaining unchanged, and that the basic economy was a savings in miles traveled relative to volume of milk hauled. When production in an area was heavy, the pickup section of a route was relatively short and the number of miles saved by E.O.D. operations was less than on longer routes. The cost difference between the two systems of hauling was thus greater on routes covering large pickup areas.

The same effect, that is, an increase in the miles saved by E.O.D. operations relative to volume of milk hauled, occured when the size of the load hauled varied but the length of the route and the volume per patron remained constant. Can and E.O.D. bulk hauling costs on routes operating at various volume levels are shown in figure 8. When production in the area was sparse and the daily can truck obtained a load of only 1,750 pounds, hauling costs were 77.3 cents per hundredweight. Costs decreased rapidly, however, as volume in the area increased and reached a level of 17.1 cents when the daily load was 10,500 pounds.

A bulk truck rendering E.O.D. pickup service and hauling the same sized load per trip as the can truck traveled only 50 miles -- the pickup mileage being reduced by 50 percent. Hauling cost on the E.O.D. bulk route at the 1,750 load level was 68.9 cents, declining to 15.9 cents when the load reached 10,500 pounds per trip.

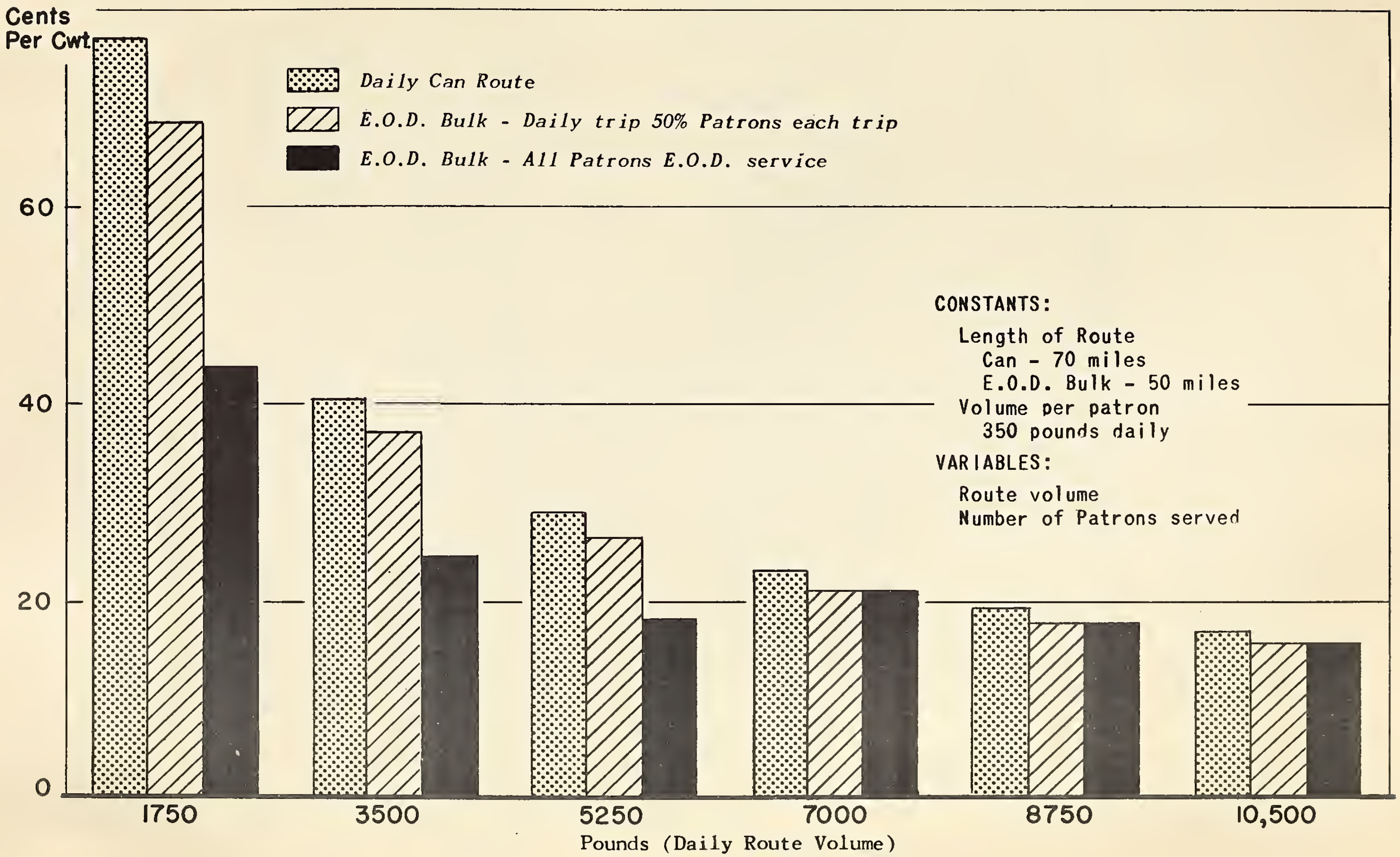
The difference in cost between can and E.O.D. bulk hauling thus decreased as the size of the load increased -- or inversely increased as the size of the load decreased. In this case the difference with full loads of equal size was 1.2 cents per hundredweight. At the 1,750 load level, however, the difference was 8.3 cents in favor of E.O.D. bulk hauling. In the first case, savings of the cost for 20 miles of truck operation were spread over 10,500 pounds of milk. In the second, the same savings are spread over only 1,750 pounds. In this illustration we have assumed that the E.O.D. bulk truck served half as many patrons per trip as the can truck, obtained twice as much milk from each patron and hauled the same sized load. The changing relationship in hauling costs was thus due to variations in the load hauled when the length of the route and the size of the producers served remained constant.

In practice, however, E.O.D. bulk trucks would not operate on such low volume routes with the same sized loads as daily can trucks serving the same area. Instead of serving half of the patrons every other day and hauling the same load per trip as the can truck -- the E.O.D. bulk truck can serve all of the patrons on alternate day trips and haul twice as much milk per trip as the can truck. The E.O.D. bulk truck can follow this practice as long as daily production in the route area is less than 50 percent of the truck's capacity.

The solid costs bars in figure 8 show the cost on such an E.O.D. bulk route making 1 trip each 2 days when the daily route volume was 5,250 pounds or less and daily trips serving half the procurement area each trip at higher route volumes. The wide difference in costs at low levels in route volume were the result of hauling twice as large loads on the E.O.D. bulk route as on a can route serving the same patrons -- a practice entirely feasible when the available production in an area was limited.

Figure 8

Daily Route Volume Related to Bulk and Can Hauling Costs



Combined Effect

Each of the analyses in this section demonstrated that the cost advantage of E.O.D. bulk hauling increased as the density of patronage in an area decreased:

1. When the length of the route was constant, the advantage of E.O.D. bulk hauling increased as the size of the patrons served increased.

2. When the length of the route was increased by lengthening the distance between patrons of constant size in the pickup area, the advantage of E.O.D. hauling increased.

3. When the length of the route remained constant and the size of the load decreased due to less patronage in a specific area, the advantage of E.O.D. bulk hauling increased.

These facts can be useful to dairy plant managers, producers, and their cooperatives considering the advisability of conversion to bulk methods of procurement. They mean that the greatest opportunity for saving in hauling costs by E.O.D. bulk operations exist when can routes are long, patrons are scattered, and resulting can hauling rates are high. On routes of equal length, however, greater savings are realized on routes serving large patrons than on routes serving small patrons. When production per mile of route is high and the distance traveled to obtain a load of milk is relatively short, can hauling costs are low and the possibilities of reducing hauling costs by bulk operations are relatively limited.

ROUTE REORGANIZATION POTENTIAL

Our analysis indicated that bulk procurement could, under conditions existing in many dairy areas, bring about reductions in hauling costs. Larger loads and less frequent service when E.O.D. operations were practiced resulted in lower per hundredweight inputs of time and mileage than are required on can routes. The potential for such reductions in inputs exists in varying degree even though the existing can routes are efficiently organized.

Numerous studies of can hauling practices have indicated, however, that many can route procurement systems are inefficiently organized. Overlapping of procurement areas of competing plants and of haulers serving the same plant are common. Many trucks operate continuously with less than practicable capacity loads.

In many cases it has been shown that rates paid haulers are not closely related to the real costs of route operation. Inputs of time and mileage are in some cases low while hauling rates paid by producers are high. Over a period of years much research evidence has been published indicating that reorganization of milk procurement systems and revision of hauling rate structures were needed. Due to numerous impeding factors, which need not be discussed here, relatively little such adjustment had taken place.

The development of a bulk milk procurement system to replace, in whole or in substantial part, an existing can procurement system gives the industry an opportunity to eliminate the inefficiencies of the existing system and to take advantage of the basic economies more or less inherent in the new system. To the extent that well organized, efficiently operated bulk routes replace inefficient can routes, one may expect reductions in hauling costs in excess of those previously indicated in this analysis.

When a bulk truck hauling a capacity load or a bulk truck serving all the patrons of a receiving plant in the route area replaces a can truck which has been hauling a 50 percent load or serving only part of the patrons in the area, real costs will be reduced accordingly. Similar economies can, of course, be made within the can procurement system but opportunities for them have existed for years and in many cases few have been made. The necessary reorganization of procurement systems as bulk methods are adopted opens the way for good management to eliminate inefficiencies in the present system.

On the other hand, an unguided "Topsy like" growth of bulk procurement routes might inherit all the inefficiencies of the can system and breed a new batch of its own. This study indicated that potential economies of bulk route operations and potential reductions in hauling costs can easily be dissipated by bulk routes serving too widely scattered patrons. E.O.D. bulk routes can serve scattered patrons more economically than can routes. Bulk routes cannot serve scattered patrons, however, as economically as they can serve patrons on a compact route. Hauling costs on bulk and can routes both increase as the length of the route increases. The rate of increase on the E.O.D. bulk route is less than on a can route but it is still an increase. In other words although long routes are more feasible with bulk operations than with can operations, short routes are less costly under either system.

SIGNIFICANCE OF COST REDUCTIONS TO PRODUCERS

Reductions in hauling costs were listed as one of the principal advantages commonly associated with bulk milk procurement operations. The nature and source of such potential reductions have been discussed in considerable detail. How significant are the potential reductions to producers? To what extent will they compensate producers for the costs of investments in equipment acquired in the conversion process?

In an area where can hauling costs average between 20 and 25 cents per hundred pounds, a potential reduction of 4 to 5 cents for the producer with average volume merits consideration. Such a savings in costs of farm-to-plant transportation of milk -- if realized and reflected to the producer directly in the form of reduced hauling rates or indirectly as part of a premium for bulk milk -- will compensate for a substantial part of the investment in bulk cooling and storage equipment on the farm.

Approximate costs of bulk tanks for farmers producing from 100 to 1,000 pounds of milk per day are shown in table 8. It was assumed in this calculation that the producer should be equipped with a tank of sufficient capacity to hold 1 or 2 days' peak production, depending on the frequency of service, plus 20 percent allowance for herd expansion. Prices used were the average of f.o.b. factory prices reported by dairy equipment manufacturers in the fall of 1954. The prices were for complete units -- cooling tank, plus refrigeration unit and necessary supplemental equipment. Most manufacturers offer substantial discounts when tanks are ordered in lots of 10 or more. F.O.B. prices are used with the assumption that discounts obtained offset freight and installation costs. Prices of tanks of identical capacity vary widely due to variations in the style, type and size of refrigeration unit, and construction materials used.

Cooling tanks for daily delivery require larger cooling units than tanks of the same size for E.O.D. delivery and are accordingly higher in price. These prices were believed to be reasonably representative of those paid by producers buying as individuals or in small pooled lots. In several cases, however, cooperatives by buying in large lots installed tanks for their members at costs substantially below those listed.

The annual investment cost -- depreciation on a 15-year life and interest at 5 percent -- varied from $91 to $244 depending on the size of the tank as shown in the two columns at the right of the table. While these costs are substantial they are not prohibitive when reduced to a per hundredweight basis and compared to potential savings in hauling costs. Such a comparison is made in table 9.

In this table, investment costs were compared with estimated reductions in farm-to-plant hauling costs arising from bulk operations. In our prior analysis of the relationship between volume per producer and hauling costs (figure 4, page 35) it was assumed that each bulk truck hauled two loads of milk each day as compared to one load hauled by each can truck. It was also assumed that E.O.D. bulk operations resulted in a 50 percent reduction in the pickup mileage necessary to serve a given group of patrons.

Table 8. -- Estimated investment in bulk farm tanks by size of producer

Average daily sales in pounds	Peak 1/ daily milk sales in pounds	Size of bulk 2/ tank required in gallons		Cost of 3/ farm bulk bank		Annual 4/ Investment	
		Daily Delivery	EOD Delivery	Daily Delivery	EOD Delivery	Daily Delivery	EOD Delivery
100	140	60	60	$1,045	$ 970	$ 97	$ 91
200	280	60	100	1,045	1,318	97	123
300	420	100	150	1,448	1,607	135	150
400	560	100	200	1,448	1,992	135	186
500	700	100	200	1,448	1,992	135	186
600	840	150	200	1,700	1,992	159	186
700	980	150	300	1,700	2,354	159	220
800	1,120	200	400	2,153	2,615	200	244
900	1,260	200	400	2,153	2,615	200	244
1,000	1,400	200	400	2,153	2,615	200	244

1/ Allows for peak production 40 percent over daily average.

2/ To handle peak production plus 20 percent allowance for possible herd expansion.

3/ Based on FOB prices reported by manufacturers.

4/ Depreciation over a 15-year life plus 5 percent interest on undepreciated balance.

Table 9. -- Bulk farm tank investment costs related to potential reduction in hauling costs

	Investment costs					
Average daily production	Bulk cooling equipment 1/	Mechanical can 2/ cooling equipment	Added costs	Savings in hauling 3/	Total bulk investment cost less hauling savings	Added investment cost less hauling savings
Pounds			Cents per hundredweight milk			
			EOD bulk pickup			
100	24.9	13.4	11.5	1.2	23.7	10.2
200	16.8	7.5	9.3	3.5	13.3	5.8
300	13.7	6.1	7.6	4.0	9.7	3.6
400	12.7	5.5	7.2	4.3	8.4	2.9
500	10.2	5.3	4.9	4.5	5.7	.4
600	8.5	4.4	4.1	4.7	3.8	- .6
700	8.6	4.4	4.2	4.8	3.8	- .6
800	8.4	5.0	3.4	4.8	3.6	-1.4
900	7.4	4.8	2.6	4.9	2.5	-2.3
1,000	6.7	4.9	1.8	4.9	1.8	-3.1
			Daily bulk pickup			
100	26.6	13.4	13.2	None	26.6	13.2
200	13.3	7.5	5.8	"	13.3	5.8
300	12.3	6.1	6.2	"	12.3	6.2
400	9.2	5.5	3.7	"	9.2	3.7
500	7.4	5.3	2.1	"	7.4	2.1
600	7.3	4.4	2.9	"	7.3	2.9
700	6.2	4.4	1.8	"	6.2	1.8
800	6.8	5.0	1.8	.2	6.6	1.6
900	6.1	4.8	1.3	.4	5.7	.9
1,000	5.5	4.9	.6	.5	5.0	.1

1/ Based on annual cost as calculated in table 7.

2/ Miller, Arthur H., Economic Aspects of Bulk Milk Handling, Unnumbered Memo paper - University of Wisconsin. Table 8, page 13.

3/ Based on assumption used in figure 4 except that bulk trucks average 1.5 loads per day and save 40 percent of can route pickup mileage when operated on an EOD basis.

Although bulk routes are operated under these conditions in some cases, savings realized under such circumstances cannot be considered typical of those logically anticipated under average conditions. Data in our files indicate that bulk trucks operating in the midwestern States average about 1.5 loads a day. The average reduction in pickup mileage resulting from E.O.D. bulk service will be less than the 50 percent maximum. Accordingly, the estimated reductions in hauling costs used for comparative purposes in table 9 were calculated on the basis of bulk trucks averaging 1.5 loads per day with a savings of 40 percent of the can route pickup mileage when operated on an E.O.D. service basis. Such factors as length of route, size of load, and the like, were the same as those used in figure 4.

Investment costs for producers equipped with bulk tanks holding 2 days' milk ranged from 24.9 cents per hundred pounds for the 100 pound producer to 6.7 cents for the 1,000 pound producer. Estimated reductions in farm-to-plant hauling costs ranged from 1.2 cents at the bottom of the volume scale to 4.9 at the 1,000 pound level with E.O.D. bulk pickup service.

Estimated reductions in hauling costs resulting from E.O.D. operations were highly significant in terms of total investment costs, except on routes composed of extremely small patrons. Even at the 200 pound per day level, the reduction was equal to approximately one-fifth the investment costs. On routes with patrons averaging 1,000 pounds of milk per day, the potential saving in hauling costs is equal to nearly three-fourths of the cost of the producer's investment in the bulk farm tank. If potential reductions in hauling costs are realized and passed on to the 1,000 pound producer, they will compensate him for three-fourths of the purchase price plus interest over a 15-year period.

Daily operation of bulk tanks results in no potential reduction in hauling costs when producers on such routes average 700 pounds per day or less. Reductions at higher volume levels cover only a minor part of the total investment costs. Other sources of savings must be relied upon to offset the major part of the total investment costs when bulk hauling service is on a daily basis.

In the long run, producers are interested in knowing whether or not savings arising from bulk handling of milk will offset their added investment costs, not total investment costs. Producers have to bear the cost of cooling and holding milk on the farm whether it is handled in cans or in bulk. More and more markets are requiring that milk be cooled to and held at temperatures of 50 degrees or less on the farm. Such regulations, in effect, require mechanical refrigeration. The day does not appear far removed when producers of milk for fluid consumption will be required, directly or indirectly, to have mechanical refrigeration. The choice which such producers must make is between mechanical can refrigeration and bulk refrigeration.

The unit investment costs in equipment for mechanical refrigeration of can milk on farms as estimated in a recent University of Wisconsin publication are shown in the third column of table 9. These included the costs of cans, can racks, and mechanical can cooling equipment. The difference between the per hundredweight investment costs in bulk farm tanks and in mechanical can cooling equipment is shown in the column headed "Added costs." The significance of potential savings in hauling costs is much greater when compared with the added investment cost. Potential reductions in hauling costs on E.O.D. bulk routes serving producers averaging 600 or more pounds of milk per day were greater than the added costs of bulk equipment. The small potential savings resulting from daily bulk operations were sufficient to cover a substantial part of the added costs when producers averaged 900 pounds or more of milk per day. The higher potential savings of E.O.D. hauling operations were more than sufficient to cover the additional cost of larger farm tanks required to hold 2 days' production.

The estimates of probable reductions in hauling costs used in this comparison were believed realistic. Costs and differences between costs, however, must be estimated under a given set of cost factors. Potential savings may vary significantly if the average volume per patron, the length of route, the size of loads hauled or the wage rates used differ from those used in this analysis. Furthermore it should be noted that these potential cost reductions referred only to those arising from farm-to-plant hauling operations. They do not include savings resulting from reduced losses of milk solids, improved quality, reduced receiving costs, or from other advantages of bulk procurement operations. The extent to which producers must rely on such other sources of revenue to cover the costs of investments in bulk handling equipment is shown by the data in the two columns at the right of table 9.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that bulk milk procurement operations can, with proper planning and management, result in substantial reductions in milk hauling costs under production conditions found in many dairy areas. Potential reductions are sufficient, if realized, to compensate many producers for all or a substantial part of their added investment in equipment.

Potential reductions in hauling costs are not identical with and do not assure actual reductions in hauling costs. Actual reductions in costs of operation of milk routes, many of them operated by contract haulers, do not necessarily result in reductions in hauling charges to producers.

The industry cannot assume that the potentialities for reduced hauling costs described in this and other studies will automatically develop into reductions in hauling costs. Neither should producers nor producers' representatives assume that hauling rates will automatically be reduced. Extensive planning and adroit management will be required if anything like the full potential in reduction of hauling rates is to become a reality.

Haphazard development of bulk routes serving a few large producers who have recognized economies in bulk operations will not result in maximum benefits to producers as a group. We do not mean to imply that all such development can be avoided nor that the large producers should defer installation of bulk tanks and the organization of bulk routes until all their neighbors are ready to convert. Much of the potential for reduced costs will be lost, however, if present bulk routes become permanent and additional interweaving bulk routes are organized as more and more producers in the area install tanks.

It must be assumed that the removal of large patrons from can routes will ultimately lead to increased can hauling rates. Increasing can hauling rates will be, in turn, an additional incentive for more producers to install bulk tanks. Unless control of the organization of new bulk routes is reasonably centralized in each market area so that the routing of trucks can be altered readily as the conversion to bulk methods progresses, economies in hauling will be minimized. Under such conditions routes serving scattered large patrons may operate at costs as low or slightly lower than old can routes -- but not as low as potential costs on a route serving all or most of the producers in the area. Costs on bulk routes serving average and smaller patrons only may easily exceed can hauling costs -- and in nearly all cases will exceed costs on routes including all producers in the area.

Bulk handling of milk is going to continue to develop and will become a common, if not the most common, method of milk procurement in most fluid milk markets in the not too distant future. Producers must benefit by operating economies -- most of them arising in the milk transportation and receiving function areas -- to compensate them for added investment in equipment on the farm. It is paramount that the industry, and particularly that segment of the industry primarily concerned with the producer's interest, take steps to assure that potential economies of the system are realized to a reasonable degree.

Managers and officers of all fluid milk marketing organizations should interest themselves in and investigate the potentialities of bulk procurement in their respective areas. We do not recommend that they promote bulk milk handling but that they formulate progressive plans of action in anticipation of producers' demands for bulk service. Bulk handling methods are not equally adaptable to conditions prevailing in all markets. The shift from cans to bulk may not be warranted in some cases, particularly in areas where the average production per farm is low. Larger producers in such areas are in many cases becoming interested, however, and the managements of the marketing organizations cannot avoid dealing with the problem.

Maximum reductions in hauling costs will be realized when entire routes and procurement areas are converted from can to bulk methods. Other studies have emphasized that maximum reductions in receiving costs will occur when receiving plants are converted to 100 percent bulk operations. Although 100 percent conversion of routes or plants cannot be attained in one step in a large majority of cases, it is nevertheless important that conversions be planned with these facts in mind.

We suggest that producers' representatives in as far as practicable retain control of the routing of bulk trucks. Development of vested interest and capitalization of such values into bulk routes, as is more or less characteristic of can routes, will result in a high degree of inflexibility and inability to adapt the bulk route structure to changing transportation requirements. In some cases outright ownership of trucks and routes may be necessary to assure adequate control and flexibility. For various reasons, most cooperatives have avoided ownership and control of milk transportation equipment and routes and have relied on contract haulers to provide transportation service for their members.

Flexibility in route organization is essential especially during the conversion period, and every effort should be made to attain it either through ownership or through contractual relationships with contract haulers. Bulk routes formed by contractual arrangements between individual producers and haulers, as has been characteristic in many areas in the past, are apt to be inflexible. Some cooperatives are attempting to provide the necessary control and flexibility in their bulk routes by buying truck tanks and leasing them to contract haulers -- who own and operate the trucks. The terms of such leases can be written so as to provide for alteration in the routing of the trucks as required.

We recommend that cooperatives and other handlers fully investigate the possibilities of E.O.D. hauling operations before producers install bulk tanks. As previously indicated, reductions in farm-to-plant hauling costs do not appear to be in the picture for average size producers in most markets unless every-other-day or less frequent service is practiced. Producers should be advised of this fact. When daily bulk hauling is practiced, savings arising from sources other than reductions in hauling costs must be relied upon to cover most of the added investment costs. In some markets E.O.D. service cannot be practiced without changes in health and sanitary regulations. Producers need specific information relative to the frequency of service on bulk routes so as to avoid purchase of tanks of too little or too great capacity. Shifts from daily to E.O.D. service or vice versa are impractical due to the relative inflexibility of holding capacity on the farm.

Annual overhead costs on bulk transportation vehicles are much higher than on can trucks commonly in use. Accordingly it is recommended that bulk routes be planned on the basis of two or more loads per vehicle per day. Failure to take advantage of the opportunity for full use of the transportation equipment will add materially to unit truck operating costs.

Bulk milk handling is generally regarded as one of the most important developments in the dairy industry in our day. The extent to which it contributes to the progress of the industry will depend largely on the skill with which the industry adapts the method to local operating conditions.

Appendix table 1. -- Investment and estimated depreciation on milk hauling equipment

Equipment	Original cost (dollars)	Estimated life (years)	Estimated trade in value (dollars)	Net depreciation (dollars)	Yearly depreciation (dollars)
Tank unit A					
Chassis	$3,000	5	$500	$2,500	$500
Tank 1/	5,300	12	500	4,800	400
Tank unit B					
Chassis	3,300	5	500	2,800	560
Tank 1/	6,000	12	800	5,200	433
Tank unit C					
Chassis	4,300	5	500	3,800	760
Tank 1/	5,700	12	500	5,200	433
Can unit A					
Chassis	2,965	5	500	2,465	493
Can body	770	12	50	720	60
Can unit B					
Chassis	2,600	5	500	2,100	420
Van body	830	8	50	780	97

1/ Includes cost value of supplementary equipment -- pump, motor, etc.

Appendix table 2. -- Regression equations

Route	Y = a + bX		Standard error	Correlations coefficient
	a	b		
	Minutes	Minutes	Minutes	
B1	6.8	.38	3.44	.57
B2	18.5	.22	9.21	.28
B3	6.5	.28	3.80	.30
C1	1.33	.438	2.27	.37
C2	1.52	.487	2.60	.52

Y = Time of farm stop.
X = Bulk route = hundredweight of milk loaded.
X = Can routes = number of cans loaded.

Appendix table 3. -- Detail of synthetic routes (supplemental to table 6, page 28 in text)

Item	Route with production density of						
	B1	B2	B3	C1	C2	B1 + C1	B2 + C2
Number of producers served							
On daily can route	8.4	6.3	15.3	18.7	18.6	11.9	9.9
On daily bulk route	12.6	9.4	23.0	28.0	27.9	17.9	14.9
On E.O.D. bulk route	6.3	4.7	11.5	14.0	13.9	9.0	7.4
Pickup mileage per trip							
On daily can route	18.5	54.0	153.0	32.6	45.4	11.9	19.8
On daily bulk route	27.7	80.6	230.0	48.2	68.0	17.9	29.8
On E.O.D. bulk route	13.9	40.3	115.0	24.1	34.0	9.0	14.9
Total miles in route							
Daily can route	32.4	125.4	279.9	47.0	94.9	25.8	69.3
Daily bulk route	41.6	152.0	356.9	62.6	117.5	31.8	79.3
E.O.D. bulk route	27.8	111.7	241.9	38.5	83.5	22.9	64.4
Total minutes per trip							
Daily can route	213.6	358.0	606.5	266.3	350.0	216.6	292.8
Daily bulk route	344.4	494.0	904.5	503.7	596.8	377.9	442.4
E.O.D. bulk route	264.5	388.9	630.8	344.7	424.2	281.8	346.7